Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, DECEMBER, 1907. No. 12.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
239 WEST 39TH STREET, NEW YORK.

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Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

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Entered as Second-Class Matter, June 1906, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, DECEMBER, 1907.

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Subscription Rate.

While in the past the yearly subscription price to ELECTROCHEMICAL AND METALLURGICAL INDUSTRY has been uniformly $2.00, postpaid to any part of the world, the increase in bulk of the copies and the resulting increase of postage to foreign countries, make it necessary to charge at least part of the forwarding expenses to our foreign subscribers. The subscription price *to foreign countries* will therefore be slightly raised, and will be in future the equivalent of $2.50, *i. e.*, 10 shillings, 10 marks, or 12.50 francs, including postage. The yearly subscription price for the United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines will remain as heretofore, $2.00.

* * *

Nitric Acid from Air.

Mr. Moscicki's account of his work on the fixation of atmospheric nitrogen, which will be found elsewhere in this issue, emphasizes the fact that there has been in recent years a change in sentiment from the spark to the arc method. Formerly sparks were considered to be more efficient than the arc for forcing atmospheric oxygen and nitrogen into a combination, but the necessity of using a great many sparks—each a small unit—necessarily led to mechanical complications and difficulties, and though these could be overcome, the first cost of the apparatus became so high as to be prohibitive. The recognition of this fact terminated Moscicki's endeavors in this direction, and also appears to have been the fundamental reason of the failure of Bradley and Lovejoy in Niagara Falls. It is clear that if a method using extended arcs can be made as effective in operation as the spark method, the former will be the more economical on account of the simpler apparatus, and hence smaller capital investment. The low efficiency of a quiet, voluminous arc results from the fact that it consists of several zones with gradually decreasing temperatures; at the place of highest temperature the concentration of nitrogen oxide in the air is a maximum, but when this gas mixture passes through the zones of lower, yet still high, temperatures, a considerable portion of the nitrogen oxide, formed before will be dissociated. The only remedy is to bring the gas mixture at once from the zone of highest temperature to a temperature so low that the speed of dissociation is practically zero (because it is only at comparatively high temperatures that any combination of nitrogen and oxygen or, reversely, any dissociation of nitrogen oxide takes place). By quick, sudden cooling the composition of the gas mixture, corresponding to the high temperature of formation, is preserved; we might say it is frozen. This is possible by using the moving arc in which all zones but that of highest temperature are suppressed. The first success in this direction was obtained by Birkeland and Eyde with their "flaming disc." But modifications may easily be devised. The "flaming ring" of Moscicki

(and others) seems, mechanically, a very simple method, and the results obtained by him in the continuation of his work will be watched with interest. But at present we must still repeat what we have pointed out before, that the commercial success of the Birkeland-Eyde process in Europe is no criterion for the United States, since it has been achieved with a power cost—$4 to $6 per horsepower-year—so low as cannot be thought of in this country.

The Iron Ore Situation.

One would not naturally expect sentiment to exert much influence upon so great a work as the development of the iron ore resources of the United States, a work which has come to involve the movement of nearly 50 000,000 tons of ore a year, the transport of millions of tons of it over distances exceeding a thousand miles and the employment of hundreds of millions of dollars of capital in mining and transportation, yet a prospect and retrospect compels the conclusion that to a certain extent various sentiments quite apart from the engineering and metallurgical problems involved have played an important part in leading the development along the lines which have been followed rather than along other lines. The iron industry has apparently reached a point where it is out of harmony with geological and manufacturing conditions. More than 80 per cent of the iron ore it is mining is from the Lake Superior region, with only about 13 per cent from the Southern field, and about 7 per cent from scattered regions. There is more ore in the Southern field above the 1,000-foot level than there is in the whole Lake Superior region, and much more still below that level. It is true that the Lake Superior ores are better than the Southern ores, but the disparity has been decreasing year by year, and as to the average of the remaining ores there may not be much difference. As to the relative cost of mining, the advantage of the Lake Superior region has been decreasing as deposits with greater and greater overburdens must be stripped. As to transport, there is no comparison; the Lake Superior ores are moved over distances of from 750 to more than a thousand miles, while in the Southern district the blast furnace can be located at the mouth of the mine. In other parts of the United States there is unquestionably several times as much ore as there is in the Lake Superior region, but development has not been sufficient to furnish data for comparisons as to relative utility.

* * *

This one-sided development is, as has been said above, quite out of harmony with geological and manufacturing conditions. The other forces which have been at work may, perhaps, be described in a certain sense as sentimental. A decade and more ago, before the pig iron producers of the Central West had become large miners of Lake Superior ores themselves, they used to sit in the ante-rooms of the Cleveland ore firms waiting for a chance to sign ore contracts. All they had to do was to sign a contract for a year's supply, making payment in twelve monthly instalments, and receiving delivered at their furnaces ore of a selected analysis running uniformly as to chemical and physical characteristics. The demand for their pig iron was increasing rapidly, and in the problems of production and distribution and the extensions to their plants they were kept very busy. The Cleveland ore firms, and later the pig iron producers as they entered upon ore mining, had no difficulty in securing funds for development. The South, on the other hand, had the greatest difficulty in securing funds for development, a difficulty which has not disappeared, and indeed was one of the principal causes which recently forced the leading Southern interest to seek shelter under the wing of the United States Steel Corporation. There has been much room for pioneer work in other districts outside of the South, but iron manufacturers, in the field or proposing to enter, had neither time nor energy for the problems which would be presented. Then, too, there was the charm of the Bessemer process. Put 10 tons of molten pig iron into a vessel costing a few thousand dollars, blow ordinary atmosphere through it for a few minutes, and get 10 tons of pretty good steel. This could be done with three-fourths of the iron ore mined ten years ago in the Lake Superior region. It could be done with practically none of the ores mined elsewhere. In those days, with scrap a drug on the market, basic open-hearth steel of better quality than Bessemer could be produced at a less cost per ton, but the plant would cost several times as much, and in an industry which was doubling production oftener than once per decade, manufacturers were looking at profits per dollar of investment rather than per ton of output. The Lake Superior idea got such a hold upon the trade that the knowledge that far less than half the total reserves are of Bessemer grade, that the basic open-hearth process is preferable, and that there are many times as much ore elsewhere, of various intrinsic values, awaiting exploitation and development has hardly yet shaken it.

* * *

In the chapter on iron ores and iron products in the forthcoming report for 1906, the United States Geological Survey takes occasion to make some estimates of the total iron ore reserves of the United States, one of the objects being to show the absurdity of Prof. Törnebohm's summary of the world's workable iron ore, made to the Swedish Parliament a couple of years ago, and crediting the United States with but 1,100,000,000 tons out of a world total of only 10,000,000,000 tons. In brief, the Survey notes that the Lake Superior region has between 1,500,000,000 and 2,000,000,000 tons, that four States in the Southern district have, above the 1,000-foot level, 2,500,000 000 tons of workable ore, that the whole Southern district has, above and below the 1,000-foot level, about 10,000,000,000 tons, and that, taking into account the older Eastern States and the West, the United States may have more than 20,000,000,000 tons of workable iron ore. Everything goes to show that iron ore, *per se*, has no value whatever, the total reserves which can be worked in this way or that way being too large to write a value upon them. They will last for centuries at a greater rate of production than the present, so that with capital doubling through compound interest many times in a century the latest ores to come into use can have no present value. A given deposit of iron ore can have a present value only through its being cheaper to make pig iron from it than from other ores which will have to be used within the period in which interest charges would not become onerous. The present values which have been assumed for and written into Lake Superior ores are not in accordance with this principle. A change in the estimate of relative values is beginning to

overtake the trade. The next great period of development will take cognizance of it, and will be based most largely upon iron ore deposits outside the Lake Superior region. Its annual rate of production, which has more than quadrupled in eighteen years, is reaching the limit, because the present capital tied up in connection with it can exhaust it in less than half a century, the fees and leases are closely held by the producer-consumer class, and they have little incentive to lock up much more capital. That new period of development will hardly come soon. The present situation is that the October rate of pig iron production in the United States, which represented nearly 28,000,000 tons annually, and was the greatest rate ever witnessed, is being decreased by much more than one-half, while blast furnaces rated at fully 2,100,000 tons annually were completed and blown in this year, yet leaving furnaces with an annual capacity well beyond 3,000,000 tons in process of construction and in many cases well advanced towards completion.

Cost of Mining.

In any business enterprise the question of accurate cost-keeping is most essential and especially necessary at this time when the general tendency is to operate on a small margin with a large volume of sales. In the manufacture and marketing of high-grade machinery, a very rational system has been devised, based on the "producing hour," to which is added "overhead expenses" and profit. This is scientific and practical for it makes the unit a clear-cut business entity. It also allows of a systematic organization on the identical plan. In the smelting of ores and the refining of metallic products, the costs are figured usually per ton of ore in smelting and per ton of bullion in refining. On this unit, the costs of flux, fuel, labor, repairs, renewals and depreciation are calculated. Then the margin of "treatment charge," less smelting costs, is simply attained. In addition the "metallurgical margin," or difference between estimated recovery and actual recovery is a further source of profit. Thus it is seen that in the smelting business, accounting is on a rational basis.

* * *

Now, in the mining business we have a very logical unit, viz.: the ton of rock raised, and it is possible to make an elaborate cost sheet, covering various items, such as power, producing labor, superintendence, repairs, etc., even to the candles used per ton of ore. This is all very fine on a theoretical basis, but it is neither scientific nor practical. There are two variable factors, the cost of development work and the life of the mine. In these two respects, we have the mining business differentiated from any other business, though it resembles in a way the lumber business. But the differences are obvious. The life of a mine and the cost of development work are mutually interdependent. For when the ore is practically played out, no development work should be done, for as no ore is left, it is bad business to attempt to find it. Furthermore, where it is possible at all to estimate rightly the life of a mine from the geology of the district, as shown by older mines, it should be possible approximately to apportion the development to correspond in a crude manner to amount of ore possible and probable in the ground. We emphasize the adjectives "rough" and "crude," because usually in the mining business future profit, based on ore estimated by geological conditions, is at best a rough and crude estimate.

We have thus shown to the reader—as he is presumably a layman, it is pardonable to assume the "ex cathedra tone"—that the question of cost of "finding the ore" is most important. It can be further stated that it is usually underestimated. Thus in one mine of which we have knowledge the ore reserves were on a conservative basis $125,000. But it had taken at least $50,000 to run 2,500 feet of tunnels, drifts, raises, cross-cuts and winzes to find that amount of ore. It was only fair to charge a like amount of money to future development work against the present reserves, for in the mining business there must be no such thing as "getting a new dollar for an old one." There must be, even on most conservative basis, a good chance for future profit. Consequently the value of the mine was not over $75,000. In the development of coal fields by diamond drilling or by churn drilling, to an engineer versed in the art, it is possible to "prospect" and develop cheaply, and also to estimate tonnage accurately. This is because of the fact that the coal measures now worked in America are uniform and often quite near the surface. In the iron fields of Michigan and Minnesota, prospecting has been aided by magnetic surveying and by drilling. Drilling has also been effective in the lead districts of Southeast Missouri. Scientific and accurate churn-drilling has been done in the zinc field of Joplin and vicinity; indeed, the future of this district in the zinc business will be aided by this method of finding ore. It is especially necessary in Joplin to drill carefully, because of the pockety and erratic nature of the ore deposits and the consequent short life of the average Joplin mine. For mining men who carry on their operations with consistent drilling, the Joplin field is to the zinc business what the Mesaba range is to the iron business.

* * *

In Leadville, Butte, Bisbee and Cripple Creek the mining costs are usually figured at from $2 to $5 per short ton, according to conditions. If, however, a careful study of these districts were made, we believe that the costs should be increased from the above figures to $4 to $10 per short ton, with the proper charges for development work against probable amount of ore a given amount of development work will find. Hence an accurate study and estimate of geological conditions is necessary. The great position of Butte in the copper business and the Coeur d'Alenes in the lead-silver business is due in large part to the persistence of the mineralization in each district. This reduces the cost of development work for the entire district and consequently more money is made, as less money is wasted in futile attempts of finding ore. The great future of Ely, Nevada and Bingham, Utah, in the copper world is due to the uniformity of low-grade deposits. In conclusion, let us reiterate the fact that mines, like people, have their period of productive life; that mines at times should be "oslerized," but that a mining company should continually develop new mines, so that its family of producing mines should have a permanent existence as a family should have a permanent existence. By applying synthetically to the mining business the principles of evolution found by the analytical methods of Charles Darwin, in a shrewd and cold-blooded manner but with philosophical insight, success and large profit can be attained. With the risk reduced to a minimum and the speculative chance for something great always possible, mining is a most attractive venture.

The Iron and Steel Market.

November has made a record for itself in the American iron and steel trade. It will go down in history as the month which has recorded the greatest decline in production, both as to tonnage and as to percentage, which has ever been experienced.

October closed with pig iron being made at the rate of 26,000,000 tons a year; November closed with a rate under 15,000,000 tons. The rate during the first three weeks or more of October had been over 28,000,000 tons, so that in the five weeks beginning late in October and embracing the month of November there was a decline in the annual rate of pig iron production of more than 13 000,000 tons, or 44 per cent. Never before in the history of the trade has there been so great a decline in point of tonnage, and never before has there been so great a decline in percentage in anything like an equal period of time. In 1903 there was a decline of a shade over 50 per cent, but it required the seven months from May to December to accomplish this, and production being on a much smaller scale that year the decline in point of tonnage was less than 11,000,000 tons a year. There has been no other decline in the history of the trade at all comparable with the present one outside of that in 1903.

The decline in steel production has been even greater than that in pig iron. The steel industry has neither accumulated stocks of pig iron, nor drawn upon stocks, as it had practically none, so that production of steel—and of finished steel products—has moved evenly with the production of steel-making pig iron. The production of foundry iron has decreased less than that of steel-making pig, partly because the consumption has been better maintained, but chiefly because many merchant furnaces have remained in operation to give themselves and their customers some stocks, and get themselves into a comfortable position for as long a shut-down as conditions may suggest. By the 1st of December the steel trade had already experienced the greater part of its probable curtailment, while with the foundry iron industry a large decrease was still to be expected. It is quite possible that the rate of pig iron production at some time in December may fall below 10,000,000 tons a year.

For months there has been good reason to expect a sudden slowing down in production at about this time, and these reports have reflected that probability, but no ordinary causes could have produced such a wonderful curtailment in so brief a period. The financial stringency all over the country was so timed as to add a compelling force to the influences which had already come into existence. There was such a tightening of funds that consumers on the one hand could not see their way clear to meeting payments, while producers were afraid to ship. Indefinite postponement of shipment on the great bulk of orders and contracts for finished steel products immediately became the rule, and for a few days in November the mails of steel producers contained little else than peremptory instructions to cease shipments.

While the future must be quite in the dark during the progress of such sweeping changes, it can be said that with the establishment of conditions calling for a cutting in half of production, not a great deal more can occur in this direction, and that with the actual movement so greatly restricted the strain on credit should be so reduced as to permit freer movements. Besides this, some actual pressing needs must be arising during this period when business is throttled. Altogether, it seems reasonable to predict a moderate improvement in buying and production by the early part of January. At the same time it is inconceivable that with such a disturbance the old order of heavy production and buying can be restored in any period of a few months. The iron and steel industry is likely to have to run at greatly reduced pressure through the major part of next year, and it may be more than a year before the rate of production of last October—which happened to be the greatest ever attained—is restored.

Pig Iron.

Sales of pig iron during November were undoubtedly the lightest for a month in many years. Only occasional small lots for prompt shipment figured at all, and there was not enough business done to establish regular market prices. Referring to asking prices rather than actual transactions, it may be said that Bessemer has declined to $19, valley; foundry iron to $18, valley, and Southern iron to $15, Birmingham, for No. 2. The decline averages about $2 a ton for the month. Present prices are purely nominal. As the majority of sellers have either blown out their furnaces or laid definite plans to do so, their real position as to prices has not been formulated. When business is resumed on a reasonable scale it is likely to be at lower prices than these, but it is not inconceivable that the level should be higher, on account of the independent position in which producers are placing themselves.

Steel.

The market has been quite uneventful. The mills have adhered to their understanding to hold billets, both Bessemer and basic, at $28, f. o. b., Pittsburg. There has been no business done at this figure, but it is doubtful if steel could have been sold at any price. Sheet bars remain at $31, Pittsburg. In some quarters there is an expectation that prices will be revised by the end of the year, but nothing definite regarding this can be known by anyone.

Finished Material.

The steel mills entered this period of universal throttling of the channels of trade with several million tons of orders on their books. Upon the great mass of this, shipment has been indefinitely postponed. Very little has been actually canceled. There has been a little new business placed, but very little indeed; and increased mill activity, if it comes, will come chiefly from the resumption of shipments upon old orders. In the main, prices have been strictly maintained, and while there may be some readjustments here and there it is probable that the steel interests will be able to hold the price level pretty steady for months, at least until the bulk of the old business has been worked off. The spirit is very strong among the producers that prices should be maintained. It is absurd to hope, however, that these prices can be maintained indefinitely. It has been repeated again and again that since prices were not advanced in time of great prosperity, they should not now be reduced. As the premises are wrong, it is unnecessary to discuss the reasonableness of the theory. Prices were advanced, but with such little friction that little heed has been taken. A price index system, devised to show the average price of finished steel products, giving each line its proper weight according to the tonnage of production, shows that the regular prices in 1902 averaged $44.00 per gross ton; that at the low points in 1904 the average was $30.71, and that present prices average $41.64. In 1897 the low points in all the history of the trade made up an average of $28.24. The present depression is not as severe as that which caused the low prices of 1897, and basic conditions are quite different, but on the other hand the present situation is a far worse one than that which produced the low points of 1904.

There has been no change in prices of finished steel products. Sheets continue to be shaded by $2 a ton from the official price of $2.60. Iron bars are quite irregular, but can be quoted at between $1.50 and $1.60, Pittsburg. The recognized prices on finished steel products remain as last quoted, f. o. b. Pittsburg, per 100 pounds:

Structural shapes, $1.70 for means and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60 base.

Sheets, 28 gauge, $2.60 for black and $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Mendelejeff Congress of Chemistry.

From the 2d to the 12th of January, 1908, the first Russian Congress of Pure and Applied Chemistry will be held at St. Petersburg, in memory of the late D. Mendelejeff, the celebrated Russian chemist.

Prof. A. Krakau, of the Electrochemical Institute of the Emperor Alexander III., Pesotchnaya 5, St. Petersburg, intends to use this opportunity to acquaint the members of the Congress—and ultimately, by means of public lectures, the more general classes of the Russian public—with the recent progress and the present condition of the electrochemical industry, especially in the United States.

For this reason manufacturers, using electrochemical processes, are requested to send to Prof. Krakau samples of their products, photographs of their works, and general information as to their products, prices, amount of power used, patents, etc. The exhibits thus obtained will form the nucleus of a permanent Mendelejeff Museum.

Electric Zinc Smelting

MR. FREDERICK T. SNYDER, whose activity in introducing the electric furnace into zinc metallurgy has been repeatedly mentioned in our columns, presented a paper on electric zinc smelting at the recent Mineral Point meeting of the Tristate Mining Association.

The author gives comparative costs of zinc smelting in two plants, each of 25,000 tons annual capacity, operating under equivalent traffic conditions in the Illinois coal field, one using retorts and the other an electric stack furnace.

"The first cost of the present type of retort plant, including land, buildings and machinery, but excluding working capital, will be some $400,000. The equivalent first cost of the electric stack plant, including steam-driven electric generating machinery, will be substantially the same. Of this $160,000 is the cost of the stack plant and $240,000 the cost of the electric generating plant.

"General operating cost items for salaries, interest and depreciation are substantially the same for the retort plant and the electric furnace plant."

The operating cost in a modern retort plant burning coal with mechanical stokers is taken as $4 per ton of raw ore. The labor in an electric stack plant "may be kept well under $3 per ton," on account of the greater compactness of the plant. "With the electric stack furnace the sulphur does not have to be roasted as low as with retorts; 6 per cent of sulphur in the electric stack furnace will give as good an extraction of zinc as 1 per cent sulphur with retort furnaces."

As to fuel, "a regenerative retort plant will burn 4,200 pounds of coal per ton of raw ore. Of this 600 pounds will be used in roasting. With the electric stack furnace it takes 1,200 horse power-hours of electricity per ton of raw ore," which require about 1,800 pounds of coal. The coal required for roasting is also one-half. "The saving is substantially 1 ton of coal per ton of ore, amounting to 75 cents."

"With the retort plant 800 pounds of reduction material will be used per ton of raw ore; with the electric stack plant 200 pounds, assuming in each case a furnace charge carrying 50 per cent of zinc. With normal prices this saving amounts to 55 cents per ton of raw ore."

The author estimates that the expense of new retorts is 40 cents per ton of raw ore, which is saved in the stack plant, but the latter requires electrodes, and their cost per ton of raw ore is estimated at 20 cents.

Summing up these differences, the electric stack plant costs $2.50 less per ton of raw ore to operate than the retort plant.

The increased recovery due to the stack plant, with zinc at 4 cents, is estimated at $4 per ton ore.

"With the electric stack plant, iron in the zinc ore improves the operation of the stack furnace. Up to the point where the percentage of iron equals one-half the percentage of silica, iron is required in the stack furnace charge and has to be added if absent. With an ore running 50 per cent in zinc, and no lime, this means that an electric stack furnace requires an iron contents of 8 per cent."

"With the electric stack furnace, any lead in the ore is reduced and saved separately, at the same time as the zinc. This makes it practicable to do rougher concentrating work and let the lead go in with the zinc, taking out only the gangue. With zinc concentrates containing 3 per cent of lead, 50 pounds per ton of raw ore, or 2½ per cent, will be saved in electric stack smelting and lost in retort smelting. At 4 cents per pound this is an item of $2.00. In addition, the lead penalty will be saved to the owner of the ore.

"Lime is required in the charge in an electric stack furnace and is permissible in the roasting, as low sulphur is not required. With limy ore this saves the penalty to the mine owner. It also makes a saving of zinc, as with no lime penalty close work is not so imperative, and less zinc is lost in the mill tailings. These items may reach $1.50 per ton.

"Summing up these savings of metals in the electric stack plant over the results of a retort plant, makes a total of $7.50 per ton of shipping ore. This, taken together with the reduction of operating expense, makes a net difference between the retort plant and the electric stack plant of $10.00 per ton of ore."

Faraday Society.

The thirty-first ordinary meeting of the Faraday Society was held on Oct. 29 at the Institution of Electrical Engineers, in London, Mr. N. T. M. Wilsmore in the chair.

The chairman announced that SIR OLIVER LODGE has accepted the invitation of the Council to succeed the late Sir William Perkin as president of the Society.

ELECTROLYSIS AT LOW TEMPERATURES.

A paper by Dr. BERTRAM D. STEELE on "the electrolysis of salt solutions in liquefied sulphur dioxide at low temperatures" was read in abstract.

This is a preliminary account of the results at present arrived at in the course of a general study of the electrolysis of salts in liquefied gases. The present paper deals with the case of a solution of potassium iodide in sulphur dioxide. Electrodes of various materials were used, and the changes at anode and cathode were carefully studied. With platinum or mercury cathodes a very rapid diminution of current (depending on the initial current density), due, in the author's opinion, to a film of sulphur, was observed. Potassium sulphite with an admixture of sulphur was after continued electrolysis found to be deposited on these cathodes. Using silver, copper, or iron cathodes of large area, a constant current was maintained, the sulphides being formed in these cases. Iodine was formed at the anode, being either liberated or found in combination, depending on the metal employed. No potassium as metal was found to be deposited on the cathode. The author concludes that sulphur cations exist in the solution.

Measurements of conductivity and ionic velocities have also been made, and the results obtained will be published in due course.

In the discussion which followed Dr. T. M. Lowry expressed his doubts as to the existence of sulphur ions. He thought secondary reactions would explain Dr. Steele's observations.

REDUCTION OF BORIC ANHYDRIDE AND SILICA BY ALUMINIUM.

A paper by Messrs. F. E. WESTON and H. RUSSELL ELLIS on "the action of aluminium powder on silica and boric anhydride" was read in abstract by Mr. Weston, who showed, on a small scale, some of the reductions described.

The authors have studied the action of aluminium powder upon boric anhydride and silica respectively. It is shown that in the case of boric anhydride the reducing action of the aluminium depends upon the fineness of both the aluminium and the boric anhydride, *e. g.*:

(*a*) Mixtures in molecular proportions of the finest obtainable aluminium powder and powdered B_2O_3 which has passed through a sieve of 14,400 meshes to the square inch react at once, in the cold, when started with a fuse of Mg ribbon and BaO_2 powder.

(*b*) Mixtures in proportion of Al_2 to $2B_2O_3$ only react when heated to dull redness in a muffle furnace.

(*c*) Similar mixtures to (*a*) and (*b*), but using B_2O_3 that has only passed through a sieve of 3,600 meshes to the square inch, only react when heated to 300° C. and dull redness respectively.

The products of the reaction were shown to be Al_2O_3 and mixtures of boron with aluminium borides, the latter predominating in the mixture containing molecular proportions and the former in the other mixture.

In the action of aluminium upon silica the authors used for the latter kieselguhr, precipitated silica, and fine silver sand. Here again the action took place more readily with the finer varieties of silica, the speed and energy of the reaction being in the order—precipitated silica, kieselguhr, silver sand.

The action took place in the cold with precipitated silica and kieselguhr on being started with a fuse of Mg and BaO_2, when the constituents in the mixture were in the ratio of $3SiO_2$ to 8Al; when the mixture contained the constituents in the ratio of $3SiO_2$ to 4Al the reaction only took place on heating the mixture to dull redness. When sand was used the mixture had to be heated to a dull redness in each case before the action commenced, and in the mixture containing $3SiO_2$ to 4Al free sand and free Al were found in the product.

The products of the reaction contained in all cases Al_2O_3, silicon (as shown by the production of $SiCl_4$), and probably some silicides of Al.

In the discussion which followed, Dr. R. Seligman suggested that some of the heat required in these reactions was furnished by the aluminium or boron, as the case may be, burning in air. The fireproof slags obtained in many cases were being used for making acid-resisting crucibles and for other industrial purposes. Dr. F. M. Perkin pointed out that the difficulty of getting a fusible slag in all cases prevented the preparation in a pure state of products like boron and silicon.

Calcium Hydride as Reducing Agent.

Dr. F. M. Perkin and Mr. L. Pratt read a paper on "the reduction of metallic oxides with calcium hydride" and illustrated some of the reductions.

Various metals can be reduced from their oxides and in some cases from their chlorides. A particularly vigorous reaction takes place with a mixture of metallic calcium and wolframite. The tungsten is melted and is obtained on cooling as a hard regulus. A fuller abstract of this paper will be given in our next issue.

CORRESPONDENCE

Presidency of the American Electrochemical Society.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—The very flourishing and progressive condition of this young giant among our national societies, makes the proper selection of a head for its next year a matter of importance. It is a question which the members of this society should decide with care, not taking simply the man most available, or the man most willing to wear the honor, but the man who by reputation, temperament and ability is best fitted to lead the society and to contribute most to its advancement.

The first, second and third presidents of the society were university professors, who gave the best they had to give to the benefit of the society; the fourth president was a consulting electrical engineer of prominence, whose labors and name lent prestige to the office; the present president is one of the most practical and industrious professors of electrochemistry to be found inside the walls of an American university. One class, however, has been conspicuous for its absence from this roll of honor—the pioneers of industrial electrochemistry. Has not the industry itself a man of sufficient prominence and ability to be worthy the honor of the presidential chair?

To be of the greatest use to everybody concerned, the society should, in its officers, policy and activities, represent the scholastic, the laboratory or experimental, and the utilitarian or industrial sides of electrochemistry. On that we are all agreed; and it can be fairly said that the society has been very creditably living up to those ideals.

It would seem now, however, that the time has arrived, at the present stage of the society's development, when the best interests of the society call for a man prominent in the electrochemical industry to step into the presidential chair, and thus to neutralize the suspicion which may prevail in some directions that the society (as represented by the majority of its presidents) has a leaning towards the academic and theoretic side of electrochemistry.

It is absolutely true that such a suspicion is not borne out by the facts, that a perusal of the *Transactions* will show as many eminently practical papers from practical men as of theoretical papers from college professors.

But is it not best to once for all meet such an attitude of mind by removing the only pretext for its existence, that is, by putting a pioneer of the electrochemical industry into the presidential chair?

Among the many investigators, developers of industries, representatives of applied electrochemistry as it exists in America, it is not easy to select the man who should thus most suitably represent the society.

However, among them is one whose labors in supplying electrochemists of all classes and in all countries with indestructible electrodes, have placed him in a class by himself, the most cosmopolitan and most representative of American electrochemical industry—Mr. Edward G. Acheson.

In electing Mr. Acheson as its president, the American Electrochemical Society will honor one who has done not only splendid work in the development of the carborundum and graphite industries, but whose work in the artificial graphite industry has really and materially assisted the development of probably half of all the electrochemical industries now in operation.

The blanks asking members of this society to nominate a president for the forthcoming year are now in their hands, and it is our earnest hope that the society will nominate the one man who, at this juncture, would most fittingly meet the needs of the position, fill the qualifications for the honor, and give international prestige to the society.

Charles F. Chandler.
Charles M. Hall.
Samuel A. Tucker.

New York and Niagara Falls.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I heartily approve the nomination of Mr. E. G. Acheson for the presidency of the American Electrochemical Society. I have expressed this opinion annually for a number of years.

Carl Hering.

Philadelphia.

Nitric Acid From Air.

Among the workers in the field of the fixation of atmospheric nitrogen by electric discharges, the names of I. MOSCICKI and I. VON KOWALSKI, in Freiburg, in Switzerland, have been noticed repeatedly in this journal. An interesting summary of their work has now been given by Mr. I. Moscicki himself in recent issues of the *Elektrotechnische Zeitschrift* Oct. 17, 24 and 31), from which the following account is taken.

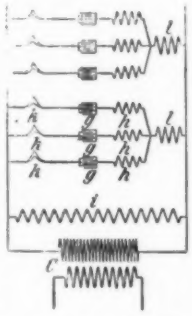


FIG. 1. — CONNECTIONS FOR PRODUCING HIGH-FREQUENCY DISCHARGES.

Mosciciki's first experiments with high-voltage, high-frequency discharges were made in 1900 in Prof. Kowalski's physical laboratory at the University of Freiberg. Among the results obtained at that time were the observations that saturation of the air with steam did not improve the efficiency essentially, while enriching the air with oxygen (so that the gas mixture contained equal quantities of oxygen and nitrogen) increased the yield by 20 per cent. The "Initiativkommittee für die Herstellung von stickstoffhaltigen Produkten" was then founded in 1901, to reduce the process to a commercial scale.

The arrangement first used is indicated in Fig. 1, 50,000-volt alternating current of ordinary commercial frequency being supplied to the system of condensers and inductance coils; *k* are the air gaps, *g* condensers, *h* small inductance coils, *l*

FIG. 2.—ELECTRIC FURNACE WITH CONDENSERS AND INDUCTANCE COILS.

larger inductance coils. The frequency of the discharges passing through the air gaps was 6,000 to 10,000 periods per second. The large inductance coil *i* served to compensate the phase difference. A special plant was erected to make the high-tension condensers. In these experiments the following facts were established:

The further oxidation of NO to NO_2 requires a comparatively long time. With a proper arrangement of the absorption towers it is possible to absorb very dilute gases. A 60 per cent concentration of pure nitric acid in water, free from nitrous acid, may be obtained by absorbing the gases in water heated to 60° C. By adding 5 per cent of a mixture of hydrogen and oxygen (detonating gas) to air it is possible to increase the yield by 20 per cent.

In 1903 a 100-hp. plant was erected in Vevey, Switzerland. A 75-kw. transformer raised the voltage from 3,600 to 50,000, the frequency being 50. The electric furnace was an iron tower of 4.6 meters height and 1.5 meters diameter. One electrode, which was common to all flames, consisted of an aluminium axle in the center of the tower, from which points projected at regular intervals. Opposite to these points the other electrodes were provided, projecting through the walls. The distance between the electrodes was 10 centimeters. The air was introduced into the tower at the bottom, and the treated air passing out from the top was led to the absorption towers.

Fig. 2 shows the furnace in the center with the sets of condensers and inductance coils placed around the furnace. The transformer is shown at the left-hand in the front. Instead of the electrical connections of Fig. 1 those of Fig. 3 were used. The numerous inductance coils *l* of Fig. 1 are omitted and replaced by two inductance coils s_1 and s_2. The two condensers C_1 and C_2 are connected at one end to the feeders and at the other end to earth. The common electrode in the center is also earthed. With this arrangement the required insulation is reduced from 50,000 to 25,000 volts.

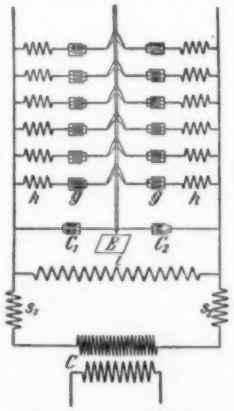


FIG. 3. — MODIFICATION OF THE ARRANGEMENT OF FIG. 1.

Fig. 4 shows the arrangement of the chemical plant. The gases coming from the furnace pass through six absorption towers. In the first two towers A and A_1 hollow balls of acid-proof stoneware are used as filling material. The next two towers B and B_1 are filled with plates according to the system of Lunge. In the last two towers C and C_1 filling material of Kypke is used.

The circulation of the gas is accomplished by means of the stoneware exhauster D, which sucks the gases from the furnace into the first tower and drives them through the following towers.

The first four absorption towers A, A_1, B, B_1 have a common reservoir with a montejus F, which raises the liquid into two upper distributing reservoirs which are connected together. By means of valves the flow of liquid to each of the four towers is regulated.

The fifth tower C has its own collecting reservoir with a montejus F, which raises the liquid into the reservoir E. This has a capacity of 600 liters and is placed at the top of the whole works. The sixth tower has its own collecting reservoir, montejus and distributing reservoir.

The gases mixed with air pass into the first tower A. The amount of liquid is limited, the temperature of the outflowing liquid is 50° C. Under these conditions nitric acid alone is formed. Any nitrous acid decomposes at once, and the escaping nitric oxide is oxidized by the oxygen of the air (with which the gases are mixed) to NO_2. This is absorbed in the next tower in which cold water is used.

In order to cool the warm gases which escape from the first tower, and in order to wet them well, a spray apparatus H is provided between the first tower and the exhauster, so that the gases are intimately mixed with liquid taken from the upper distributing pipes.

In the second, third and fourth tower the same liquid is used

as in the first. But in these three towers it is cold and more liquid is employed than in the first tower where it is warm. The largest part of nitrogen oxides is absorbed in these four towers.

In the fifth tower the quantity of liquid used is as much as in the first four towers together. This results in a much lower concentration in the fifth tower and in a much more energetic absorption of any rests of nitrogen oxide.

As long as the concentration of the acid in the first four towers is not sufficiently strong, the outflow of the first tower

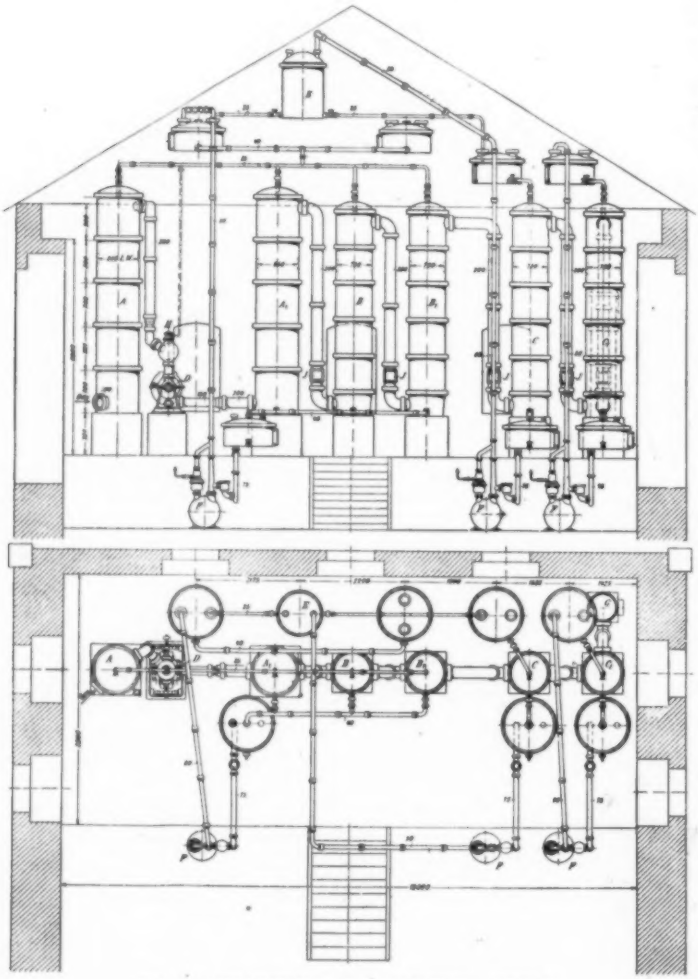


FIG. 4.—ARRANGEMENT OF ABSORPTION TOWERS.

is connected with the common collecting reservoir. By the constant heating of always fresh parts of the liquid its content of nitrous acid is maintained low. When the concentration has been brought up to the desired percentage, the valve between the first tower and the collecting reservoir is closed and the acid is slowly taken from the first tower through a special outflow. Since it is warm it is absolutely free from nitrous acid.

After the greatest part of the concentrated acid of the first four towers has been removed, the less concentrated acid of the reservoir E of the fifth tower is introduced into the two distributing reservoirs of the first four towers to be further concentrated in the latter. A new quantity of water is introduced into the fourth tower.

Since part of the nitrous acid decomposes at ordinary room temperature, traces of nitrogen oxides remain in the gases. In order to absorb these, concentrated soda solution is used in the sixth tower, whereby chiefly sodium nitrite, $NaNO_2$ is formed.

The seventh tower G, which is much smaller, is filled with hollow balls, and no absorbing liquid is employed in it. Any liquid particles carried with the air from the sixth tower are here arrested. The escaping gases pass into the atmosphere.

This scheme failed for the following reasons. In the first place the cost of installation was pretty high. The many flames required considerable complicated and expensive electric apparatus. When it was attempted to increase the energy in each flame it was found that the yield was diminished. Moscicki, therefore, decided to entirely give up the high-frequency experiments and to proceed with an entirely different system.

* * * * * *

In the new system of Moscicki the magnetic deflection of an arc is used. This is also employed in the well-known system of Birkeland and Eyde, but the method is a different one.

The study of a quiet flame shows different zones within the flame. Only the hottest zone, however, is useful for oxidation of the nitrogen. Within this hottest zone a maximum amount of nitrogen oxide is produced, which, when coming into the cooler zones is again decomposed. It is, therefore, important to suppress the cooler zones. This is accomplished by magnetic deflection of the flame. The magnetic flux only sets those parts of the flame into motion which carry the electric current, while, on account of the rapid moving, the less hot zones are completely suppressed.

FIG. 5. REVOLVING FLAME.

The method employed by Moscicki is very simple and is based on the use of two concentric ring electrodes (Fig. 5). The arc passes from one ring E_1 to the other E_2 in radial direction. A magnetic flux is provided perpendicular to the plane of the drawing. The arc is thereby deflected and revolves continuously around in the annular space between the two rings. The revolving arc gives the appearance of a luminous ring between the two ring electrodes.

On the basis of this principle the furnace shown in Fig. 6 is constructed. The arc plays between the copper cylinder *a* and the copper rod *b*. In order to keep the arc at the lower end of *b* a projection *k* is provided on the inner surface of the cylinder *a*.

The copper rod *b* is hollow for the sake of water cooling. The external diameter of this copper rod is 6 centimeters. The internal diameter of the copper cylinder *a* is 15 centimeters, so that the distance between the two copper surfaces is 45 millimeters. However, the distance between the projection *k* and the lower end of the copper rod *b* is only 15 millimeters; *c* is of porcelain, to insulate the inner copper cylinder from the outer one. The gases are introduced through *e* and flow in the direction of the arrows, leaving the furnace into the refractory clay pipe *g*.

The magnet coil *h* produces the magnetic field, and the outer copper cylinder *a* as well as the magnet coil are insulated by means of oil filled into the reservoir *m*. The oil is kept cool by means of the water circulation *i*.

The experiments were first made with alternating current of 50 periods. With an air gap of 15 millimeters at the place of the arc a voltage of 3 000 was required.

To light the arc the arrangement, illustrated in Fig. 7, was developed by Mr. Moscicki. The arc F plays between the electrodes E and E_1. The alternating-current supply circuit A, B is connected directly to the two electrodes E and E_1, and also to the primary of a transformer T, which permits raising

the voltage to, say, ten times the normal value. S, L and D are inductance coils, K condensers, *f* a spark gap. The transformer T supplies to the two conductors *a* alternating current of normal frequency, which discharges through the spark gap *f*, and thus produces high-frequency alternating current, which then bridges the gap F so that the arc is lighted.

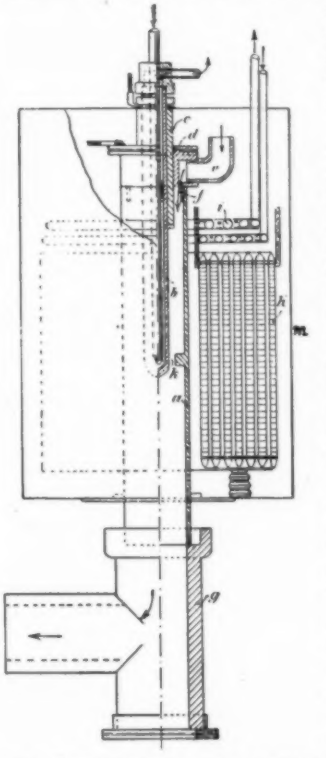


FIG. 6.—REVOLVING-FLAME ELECTRIC FURNACE.

Tests lasting from 1 to 4 hours under different conditions and consuming from 12 to 27 kw. gave as the concordant result a yield of at least 60 grams HNO_3 per kilowatt-hour, for this small furnace and the comparatively small energy quantities employed. It was found that with higher speed of the air in the flame the yield was increased.

The above figure is equivalent to 525 kg. HNO_3 per kilowatt-year. This is considered to be the minimum and might be guaranteed. The experience of the author seems to prove, however, that for the dimensions of the furnace employed a much greater amount of energy should be consumed in the flame. With a corresponding increase of the amount of air treated and with a much higher speed of the air better results are expected.

While this furnace can be used with alternating current it is particularly adapted to direct-current operation. Preliminary tests with direct current have shown that a supply pressure of 1,500 volts is sufficient. In this case the flame revolves continuously in one direction and the speed of the rotation is absolutely uniform, as is the energy consumed per unit of time. With alternating current the energy in the flame pulsates, but this is not the case with direct-current operation. The use of direct current has the further advantage that no auxiliary appliances besides the magnet winding are required.

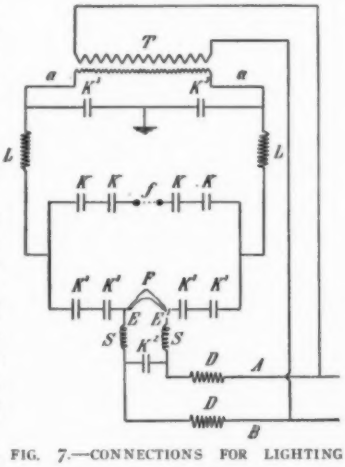


FIG. 7.—CONNECTIONS FOR LIGHTING THE ARC.

The furnace is connected directly to the terminals of the generator, but under such conditions that the direct-current dynamo supplies only a single furnace, or if several furnaces are fed they must be connected in series. The dynamo must be provided with a compound winding, which counteracts the shunt winding and prevents the current from rising beyond a permissible maximum value. Ninety-nine per cent of the total energy at the terminals of the furnace are consumed in the flame itself, since the magnet coil, which is the only auxiliary apparatus, consumes scarcely 1 per cent of the total energy in the case of a 500-kw. furnace. It is further believed that the furnace will be well suitable for treating air under pressure. Since the results so far obtained are quite satisfactory they are to be continued on a larger scale.

* * * *

At the recent seventy-ninth Versammlung Deutscher Naturforscher und Arzte, in Dresden, an interesting paper on the same subject was presented by Dr. BRION. The paper may be found in full in *Physikalische Zeitschrift*, Oct. 24. As a matter of fact, he described luminous-ring experiments in which an arrangement was used by him and Dr. Mahlke, which is practically identical with that of Moscicki. It is also mentioned that an analogous patent specification by Pedersen exists (German patent 183,-041).

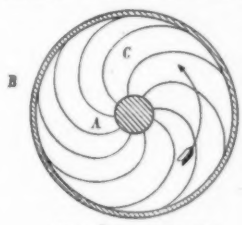


FIG. 8.—REVOLVING FLAME.

Fig. 8 shows a disc A and a concentric ring B which are in the same horizontal plane and form the two electrodes. A magnetic field is produced perpendicular to the plane of the arc. It is produced preferably by means of a coil, which is fed with the same current which produces the arc, so that in the case of alternating current the variations of the field strength are in phase with those of the arc. The arc is forced to rotate, but does not remain straight, since near the periphery B the linear speed is greater than near the disc A. The arcs assume, therefore, a curved shape, as shown in the illustration. The experiment is stated to succeed equally well with direct current and alternating current.

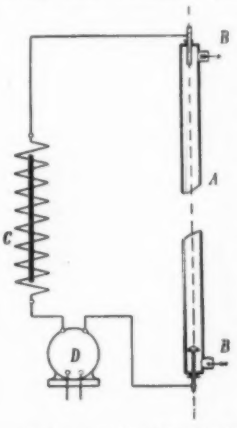


FIG. 9.—ARRANGEMENT OF BADISCHE ANILIN U. SODA FABRIK.

If the speed of rotation is large enough the experiment gives the impression of a uniformly luminous ring. The author doubts, however, whether the whole ring participates uniformly in the passage of the current. It is more probable that certain distinct paths only act as carriers of the current. It is improbable that in this luminous ring or in the Birkeland-Eyde luminous disc the temperature is as high as in a strong, quiet arc. In the latter it is about 4,000° absolute temperature. Birkeland assumes the temperature of his flame disc to be 3,200° C. From Brion's experiments it might be estimated that his luminous ring has a temperature of 2,700° C. in the average.

The yield was found by Dr. Brion to be practically the same with direct current and with alternating current and to increase greatly with the length of the arc. In his experiments in which 3 to 5 kw. were employed, the yield was not greatly different from Birkeland's result, namely, 400 to 500 kg. of HNO_3 per kilowatt-year, with a concentration of 1 to 1.5 per cent in the gases.

Finally, another arc system may be mentioned, that of the Badische Anilin and Sodafabrik. It is based on the fact that a quiet, continuous arc of several meters length may be produced if enclosed within a tube of suitable diameter. The principle is indicated in Fig. 9, where D is the dynamo, A the tube in which the arc is produced between the electrodes B and B_1, while C is an inductance coil. The arrows indicate

the flow of the air, which is pressed into the tube at the bottom. It is stated that it is possible to consume several hundred kilowatts continuously within a single tube. While nothing is known on the details of construction of the apparatus, it is reported that the yield of nitric acid as well as the concentration of the gases is somewhat higher than in the Birkeland-Eyde process.

Vanadium.

Mr. J. Kent Smith, who has long made a specialty of vanadium and vanadium steel, presented a paper on "The Present Source and Uses of Vanadium," at the Toronto meeting of the American Institute of Mining Engineers. The paper is printed in full in No. 17 (September) of the *Bi-Monthly Bulletin* of the institute.

Mr. Smith also introduced a discussion on vanadium steel at a recent meeting of the Engineers' Society of Western Pennsylvania. This discussion is printed in full in the October issue of *Proceedings* of the society.

In his American Institute paper Mr. Smith first refers to the opening up of a large deposit of vanadium sulphide ore in Peru, South America. The mine is owned by the American Vanadium Co., of Pittsburg, Pa. The ore contains 40 per cent of vanadium sulphide, 31 free sulphur, 14 silica, 4 iron sulphide, besides nickel sulphide, molybdenum sulphide, alumina, lime, etc. Being a free-burning ore it is calcined with ease, losing 45 per cent of its weight in the process.

The calcined ore has the following analysis:

	Per Cent.
Vanadic oxide V_2O_5	58.08
Iron oxide	4.98
Molybdenum oxide	2.62
Nickel oxide	2.24
Silica	25.00
Alumina	4.52
Lime, magnesia, potash, soda, etc.	2.56
Sulphur	0.23

Vanadium is a silvery white metal of high melting point—said to be 2,000° C., and, at all events, higher than the melting point of platinum—so that its commercial use in the metallic form is practically restricted to its use as a refractory metal (in the filaments of electric lamps, for instance). An alloy of iron with vanadium in the proportion of two parts of iron to one part of vanadium has a melting point of 1,375° C., or more than 100° C. below that of mild steel; and it is in this form that the metal is marketed for the use of the steel maker.

The old custom of judging a steel by its resistance to static load, and the amount it would stretch under such load, gave a certain general guide as to the behavior of metal under conditions of engineering practice which are now rapidly being left behind. Even under these conditions, mysterious failures occasionally occurred, which, it is now evident, had their origin in the inability of the metal to resist strains applied in a totally different manner from that in which it was tested.

As the requirements of modern engineering construction became more and more drastic respecting the power of resistance to rapidly repeated strains and shocks, accompanied, of course, by increased demands as to actual strength, the old test conditions were still further receded from in practice; and it became necessary to resort to alloy-steels.

"Here some success was scored; but the true requirements were nevertheless lost sight of, and the metal was still judged almost entirely by its behavior under static loads. With the same ductility, an increase in the strength was looked upon as the one desirable thing, although it is now recognized that this improvement in strength, if attained at the expense of dynamic properties in the original steel, is, in most cases, of comparatively little use to the engineer. In short, we lost ourselves in straining after something which we did not want, and which we attained only at the expense of something we did want."

Since, in modern machine construction, and especially in those parts which are liable to repeated stresses, to alternating stresses, to simple, repeated or alternating impacts, and to fatigue (which is the outward and visible sign of intermolecular vibratory deterioration), a new field has been opened, and in this field vanadium has been found, by extended experiment and practical experience, to be uniquely valuable. As to static properties, vanadium intensifies greatly the strengthening effect of another ingredient, such as chromium, thus enabling the proportion of the latter to be so reduced as to avoid "poisoning" the metal with regard to desired dynamic qualities. Moreover, vanadium is itself highly contributory to the dynamic excellence of mild steel. By retarding segregation, it renders the metal particularly susceptible to enormous improvement by tempering and heat treatment generally. By virtue of this characteristic, steel can be "automatically" rendered highly resistant to wear and abrasion. Again vanadium toughens steel; confers upon it great power of resistance to torsional rupture; in a word, endows it with increased "life" in practical use.

Being a powerful "medicine," vanadium is used in small doses only. In engineering steels, the maximum proportion required seldom exceeds 0.2 per cent. By its judicious use, combinations are thus made possible which could not be formed without it, and which permit the successful fulfillment of complicated requirements, whether chiefly static, chiefly dynamic, or divided more or less equally between the two classes.

Table I.—Properties of Vanadium Steel Compared with Some Other Steels.

Test	For Comparison. 1. Carbon "Axle" Stock.	For Comparison. 2. Nickel "Axle" Stock.	Dynamic. 3. Vanadium Axle Steel	Combined. 4. Vanadium Crank-shaft Steel.	Static. 5. Vanadium Continual Mesh Gear Steel.	Nature.
Yield-point, pounds per square inch	41,330	42,270	63,570	110,100	224,000	Static.
Ultimate stress, pounds per square inch	65,840	87,360	96,080	127,800	232,750	Static.
Ratio	0.62	0.56	0.66	0.87	0.96	Static.
Contraction of area, per cent	61	58	61	58	39	Static.
Elongation, per cent on 2 inches	42	34	33	20	11	Static.
Tortional twists	2.6	3.2	4.2	2.5	1.8	Static.
Alternating bends	10	12	18	10	6	Intermediate.
Pendulum impact, foot pounds	12	14	16.5	12	6	Dynamic.
Alternating impact—number of stresses	960	800	2,700	1,850	800	Dynamic.
Falling weight on notched bar—number of blows	25	35	69	76	..	Dynamic.
Rotary vibrations—number of revolutions	6,200	10,000	67,500	..	..	Dynamic.

How these varying and partially contradictory demands are met by vanadium is shown in Table I., which contrasts the properties of vanadium steel with some other steels. The data presented in this table are stated by Mr. Smith to have been obtained under like conditions of testing.

In his address before the Engineers' Society of Western Pennsylvania, Mr. J. Kent Smith covered practically the same field so that we will notice only those points which are new. Mr. Smith referred to the fact that we talk about steels of a certain "complete analysis," but the so-called complete analysis is, after all, very incomplete. We do not reckon in it the estimation of elements which here are most dangerous. "There is no doubt one of the commonest of such is oxygen, a terribly mischievous thing in the wrong place. I firmly believe, that in fairly easy service many steels fail chiefly on account of their oxygen contents; for I have never yet found steel oxidized in the furnace to stand repeated strains as well as properly finished steel."

One of the beneficial effects of vanadium is that it deoxidizes steels. To remove all the oxygen by means of vanadium would, of course, be very expensive. The vanadium should only be used to reduce the last traces of the oxygen. Vanadium also removes nitrogen, and this is of equal importance.

Mr. Smith also gave some data on the use of vanadium steel for crankshafts, springs and rails. With regard to the rail question, he said that "the trouble is not, as some newspapers say, all due to the effect of piping, nor to the effect of rushing through over-crowded mills, nor is it due to initial brittleness; it is mainly due to the potential brittleness, and we must retard the development of this brittleness in order to arrive at the true solution of the problem. Other causes are certainly contributory, and no sane man will maintain that a segregated rail is as good as an unsegregated rail, or that it does not matter if the rail is piped. Eliminate the segregation, eliminate the piping, and we are two steps to the good, but we are not touching the real root of the difficulty. Vanadium is the certain cure here, and the increased wear of vanadium steel should so make up for the increased first cost as to lead us to gain in safety (or insurance) at little or no additional expense in the long run. An adequate discussion of this subject would occupy a very large amount of time."

In Swedish steels, Mr. Smith has found by numerous analyses a small content of vanadium (in the average 0.05 per cent), and he believes that it is this small amount of vanadium which gives to some Swedish irons their property of resisting vibrations, etc.

There was a very extended discussion in which Mr. C. C. Smith and Mr. R. A. McDonald confirmed many of the statements of Mr. J. Kent Smith, with respect to the good effect of vanadium.

Mr. C. C. Smith used vanadium steel for locomotive frames and had "no hesitancy in saying that the best heat of steel they have ever made was the one made of vanadium." He has also made various tests, among them the following:

"This (showing samples) was a rather severe test. I took two pieces of steel 1 inch by ½ inch and bent them to an angle of about 90°. I then straightened them out and bent them the other way to about 90° and then back again, etc. That was a more severe test than I had intended. I only intended them to be straightened and bent back the same way. Our ordinary steel bent twice to 90°, and the third time to about 75° when it broke. The vanadium steel bent four times to 90°, and broke at 90° on the fourth bend. It showed, perhaps, 30 per cent better bend than our ordinary steel."

The tensile strength and elastic limit were both increased materially, and the reduction and elongation were reduced in the vanadium steel in comparison with their ordinary steel. "This indicates these bending tests mean that vanadium represents more even than my reports show. We can get practically the same elongation and reduction with 82,000 pounds tensile strength carbon steel, but we cannot get as high an elastic limit in 82,000 tensile strength carbon steel, and it would not give anything like the bending results we got from the vanadium steel."

The question of cost was then brought up and Mr. J. Kent Smith stated that the cost of vanadium alloy is $5.00 per pound of vanadium content, and that it must be taken into consideration that the maximum quantity of vanadium necessary to be used is about 0.20 to 0.25 per cent.

Mr. F. N. Speller remarked that it is pretty safe to assume that we do not get any vanadium content in steel until all the oxygen has been satisfied. How far is vanadium responsible for the rather remarkable dynamic properties we get in vanadium steel, and how much of this is due to the more thorough deoxidization which we perhaps never got before?

Mr. J. Kent Smith replied that it is perfectly feasible to finish an ordinary open-hearth heat so that it is practically free from oxygen, and when adding vanadium, about 90 per cent of it will be actually added to the steel. To the question of Mr. Speller whether one has to use two ladles there, Mr. Smith replied: "No, you can do it perfectly in the one ladle. Certainly, in my practice in Europe I used two ladles in order to thoroughly deoxidize the steel in the first ladle, as I found that the increased economy and regularity obtained more than paid for the extra trouble in the lining of the second ladle. One should deoxidize the steel very thoroughly before adding the vanadium, and it is easily feasible to so deoxidize in the furnace. Of course, if we add the manganese in the furnace, we have to look for a greater manganese loss. Where I use two ladles I do all the deoxidizing in the first ladle, then teem through a large nozzle into the second ladle. It is most practicable to do this where one is dealing with large sized casts, as you have no heat reserve to warrant using two ladles when you have only two or three tons. With a 15 or 20-ton cast, it is practically easily possible to use two ladles, tapping very hot into the first ladle and seeing to it that the nozzle and stopper of the first ladle are big enough."

Mr. Alfred Sang brought up the use of vanadium steel for rivets and bolts, especially for automobiles where there is a good deal of shock. Mr. Smith replied that for rivets, vanadium steel has proven very useful in practical work. The addition of vanadium to ordinary pure dead, mild steel, practically produces something akin to Swedish steel, and it is well known that Swedish steel is much better for rivets than is ordinary open-hearth steel. Mr. R. A. McDonald remarked that he had never found any vanadium in Swedish iron, but Mr. Smith thought this was due to the brands used by him. "We used a good many thousand tons a year of mild Swedish steel, and the average vanadium in it was 0.05 per cent."

Technical Analysis of Vanadate of Iron.

BY ARDEN M. WILSON.

The determinations ordinarily required for each sample are vanadium, iron, silica and loss on ignition.

Vanadium, iron and silica are determined with one weighing as follows:

Place .3 gram of finely powdered vanadate in an 8-ounce Erlenmeyer flask and evaporate on the sandbath to dryness with 40 c. c. dilute HCl (1:3). Take up with 10 c. c. concentrated HCl and heat to boiling. Dilute with 30 c. c. hot water, heat to boiling for several minutes and filter out the silica, letting the filtrate run into a small Erlenmeyer. Ignite and weigh SiO_2 as usual. The purity of the silica may be tested if desired by evaporation with HF and a few drops of H_2SO_4, the true silica being obtained by loss in weight.

To the filtrate from silica add 4 c. c. conc. H_2SO_4 and evaporate to white fumes. Cool and add 30 c. c. cold water and boil until everything is in solution. Transfer to a tall

narrow beaker with a small amount of hot water so as to keep the volume of the solution about 40 c. c. Heat to boiling and add H_2O_2 (3 per cent solution) until a permanent dark red color is obtained, then cover the beaker with a watch-glass and add carefully concentrated caustic soda solution until all iron is precipitated. (The precipitate should be reddish in color. If dark brown or greenish, more H_2O_2 must be added.) Boil for several minutes, then dilute to about 200 c. c. with hot water and heat to boiling. Let settle a few minutes and filter rapidly, allowing the filtrate to run into a 600 c. c. Erlenmeyer.

Wash thoroughly with boiling water, cleaning out the flask carefully so as to get all the ferric hydroxide on the filter. The filtrate should be clear and colorless; a yellow color usually indicates a trace of iron. Cool the filtrate somewhat and add conc. H_2SO_4 until a decided acid reaction is obtained upon testing with litmus. Heat to boiling and reduce the vanadium with excess of strong SO_2 water. Now boil off the excess SO_2 while passing CO_2 gas through the solution. Titrate with potassium permanganate until a pink color is obtained that does not fade when the solution is brought to a boil. Again reduce the boiling solution, which should be about 400 c. c. in volume, being very careful to add sufficient SO_2 water so that a strong odor is obtained after shaking. Boil off excess SO_2 and titrate hot with permanganate to the first pink color permanent after thorough stirring. The end-point by this double reduction is sharp, but the pink color will fade in a few minutes. This slow fading of the color may be disregarded, as the first persistent pink tinge is the true end point.

The precipitated iron is dissolved on the filter with hot dilute H_2SO_4 (1:5), allowing the filtrate to run into an 8-ounce Erlenmeyer. About 30 c. c. of the dilute acid will be required, and a large excess should be avoided. Add 10 c. c. conc. HCl and 3-5 grams of granulated zinc, and allow to stand until colorless, then add about 25 c. c. cold water and 10 c. c. conc. H_2SO_4 to dissolve excess of zinc. When all zinc is dissolved, fill flask with cold water, shake and filter through a cotton plug, letting the filtrate run into a large beaker. Wash well with cold water and make up bulk of solution equal to that used in standardizing the permanganate and titrate at once for iron.

The separation of iron and vanadium by means of caustic soda is ordinarily complete in one precipitation, but the precipitate of ferric hydroxide is usually tested for vanadium by adding H_2O_2 to a little of the sulphuric acid solution of the iron. If a red color is obtained, the precipitation is repeated and the filtrate added to that obtained from the first precipitation.

The filtrate from the iron may be tested by acidifying a few drops with HNO_3 on a spot-plate and adding KSCN, a red color indicates iron. A very slight reddish tinge may be disregarded, as it indicates only a trace of iron, but if a strong test is obtained the analysis should be rejected. The color of the filtrate from the precipitated iron is usually taken to indicate whether or not iron is present in quantity sufficient to materially affect the results. A colorless filtrate ordinarily means a complete separation.

The loss in weight upon igniting a sample of vanadate of iron is due chiefly to the giving off of moisture and free chlorine.

Take 1 gram and place in a small porcelain crucible.

Heat carefully at first; then at a strong heat until no more chlorine is evolved. This may be determined by means of a strip of filter paper which has been dipped in a solution of KI and starch. As long as chlorine is given off it will color the paper blue. Finally, cool in a desiccator, weigh and calculate percentage loss in weight.

Vanadium Alloys Co.,
Newmire, Col.

Metallurgical Calculations.

By Jos. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.

Electric Smelting of Copper Ores.

The use of electrothermal processes for smelting copper ores has been proposed in recent years, and in a few cases experimentally tested. The whole question depends on the recognition and appreciation of a few fundamental facts. By far the great bulk of all copper ores are sulphide ores, and in many cases the sulphur and iron present are sufficient heat producers to allow of the smelting of the ore simply by the heat of their oxidation, if the operation is skillfully conducted. Such is the basic principle of pyritic smelting, and whenever it can be applied it is very economical to do so, and electric processes have no chance of an application.

Other ores of copper contain so small an amount of the metal that the result of the smelting down of the whole to a fluid mass, by any method of fusion, would not repay the cost of the operation. Some such ores can be treated by aqueous and other methods not involving fusion, with a margin of profit to pay for the operation.

The only field for electrothermic processes appears to be in the smelting down of ores carrying too little sulphur to be "pyritically" smelted, and which require, as usually treated, the use of carbonaceous fuel to assist the fusion. Wherever such fuel is expensive, and electric power may be obtained at a low price, an electrothermic process might be theoretically possible and profitable.

Such conditions may easily occur in the vicinity of copper mines. Situated frequently among the mountains, remote from railways and cheap fuel, they frequently are near large water powers which would furnish cheap electric power. Some may be even so situated that concentration of a very lean sulphide ore to matte by use of fuel, or by mechanical concentration, would be unprofitable, and yet a concentration or simple melting to matte by electrically-generated heat be profitable.

There are, so far as the writer knows, no electrothermal processes yet in commercial operation on copper ores, yet they have been tested experimentally with promising results. Vattier, for instance, conducted experiments at the Livet works of the Compagnie Electrothermique Keller et Leleux, on April 23, 1903, in the presence of several distinguished metallurgists, such as Mr. Stead, of Middlesborough, Mr. Allen, of Sheffield, and Mr. Saladin, of the Creusot works. The ores were Chilian ores sent by the Chilian Government to test the possibility of electric smelting, taken from the "Vulcan" mine, owned by G. Denoso, and low-grade ore from Santiago. At the mines, coke costs $20 per ton, but the slopes of the Andes afford a fine opportunity for developing large water powers cheaply; it is estimated that the total cost of electric power delivered should not exceed $6 per kilowatt-year. A detailed account of these tests can be found in the appendix to the Report of the Canadian Commission on Electric Smelting, 1904.

Problem 121.

Vattier mixed his rich and poor Chilean ores to a charge consisting of

	Per Cent.
Copper	5.10
Sulphur	4.13
Iron	28.50
Manganese	7.64
Silica	23.70
Alumina	4.00
Carbonic acid	4.31
Lime	7.30
Magnesia	0.33
Phosphorus	0.05

This was charged directly into a shaft furnace 1.8 meters long, 0.9 meter wide and 0.9 meter high. The melted materials ran out into a forehearth 1.2 meters long, 0.6 meter wide and 0.6 meter high. Two carbon electrodes, 30 centimeters square by 170 centimeters long, were used in the smelting chamber, and two electrodes, 25 centimeters square by 100 centimeters long, were put in the forehearth to reheat it for tapping.

The matte obtained analyzed:

	Per Cent.
Silica	0.80
Alumina	0.50
Iron	24.30
Manganese	1.40
Sulphur	22.96
Copper	47.90

The slag contained:

Silica	27.20
Alumina	5.20
Lime	9.90
Magnesia	0.39
Iron	32.50
Manganese	8.23
Sulphur	0.57
Phosphorus	0.06
Copper	0.10

The current used was 4,750 amperes at 119 volts; power factor = 0.9; 8 000 kilograms of ore mixture were smelted in 8 hours; consumption of electrodes 50 kilograms.

Required:

(1) A balance sheet of materials entering and leaving the furnace per hour.

(2) A balance sheet of the heat development and distribution in the furnace.

(3) The saving in cost of treatment per ton of ore, assuming electrodes to cost 4 cents per kilogram, coke $20 per metric ton, and that when coke is used one-third of its calorific power leaves the furnace in the escaping hot gases. Assume all other costs similar, except that air blast costs $0.10 per ton of ore smelted additional. Electric power $6 per kilowatt-year.

(4) If the resulting slag were smelted electrically for ferro-silicon, at an expenditure of 0.75 electric horsepower-year per ton of ferro-silicon obtained, and other smelting costs were $10 per ton, how much ferro-silicon would be obtained per ton of copper ore treated, and what would be its cost?

Solution:

(1) Balance sheet per 1,000 kg. of ore.

	Charges.	Matte.	Slag.	Gases.
Ore: 1,000 kg.				
Silica	237 kg.	1	236	...
Alumina	40 "	0.5	39.5	...
Iron	285 "	25	260	...
Manganese	76 "	1.5	74.5	...
Sulphur	41 "	24	5	12
Copper	51 "	50	1	...
Carbonic acid.	43 "	...	...	43
Lime	73 "	...	73	...
Magnesia	3 "	...	3	...
Oxygen	137 "	2	74	61
Electrode:				
Carbon	6 "	...	...	6
		104	796	122

Composition of Slag.

	Calculated.	Analyzed.
Silica	29.5 per cent.	27.2 per cent.
Alumina	5.0 "	5.2 "
Lime	9.2 "	9.9 "
Iron	32.5 "	32.5 "
Manganese	9.3 "	8.2 "
Sulphur	0.6 "	0.6 "

Heat Development.

Electric energy per hour:

$4,750 \times 119 \times 0.9 = 509$ kilowatts.

$509 \times 860 = 437,750$ Cal. per hour.

Oxidation of carbon:

$6 \times 4,300 = 25,800$ " "

463,550 " "

Heat Distribution.

Heat in matte:

$104 \times 270 = 28,080$ Calories.

Heat in slag:

$796 \times 400 = 318,400$ "

Heat in gases = 30,000 "

Loss by radiation and conduction = 87,070 "

463,550 "

The radiation and conduction loss is 19 per cent of the total heat generated in the furnace—a satisfactory showing. The useful effect of the furnace is nearly 75 per cent, reckoning as usefully applied heat that contained as sensible heat in the melted matte and slag.

Nearly 90 per cent of this usefully applied heat is contained in the slag.

(3) If coke were used instead of electric heat, enough coke would have to be used to furnish 433,550 Calories plus the heat in the gases. Since the latter is assumed to be one-third of its calorific power, the coke must have a calorific power of 650,325 Calories, which at 7,000 Calories per kilogram would require 93 kg. of coke per 1,000 of ore smelted. The costs of coke and blowing engine would therefore be

Coke,	$93 \times \$0.02 =$	$1.96
Engine,		0.10
	Sum	$2.06

The cost of electrodes and electric energy, which would relpace coke and blowing engine, would be:

Electrodes,	$6 \text{ kg.} \times \$0.04 =$	$0.24
Power,	$509 \text{ kw.} \times \frac{6.00}{8,760} =$	0.35
	Sum	$0.59
	Saving	1.47

(4) The resulting slag contains, according to the balance sheet, 260 kg. of iron, 74.5 kg. of manganese, and 236 kg. of silica equal to 126 kg. of silicon.

It should produce, if completely reduced, 460 kg. of alloy (omitting the carbon it might contain) of the approximate composition:

Fe	260 kg. =	56 per cent.
Mn	74 kg. =	16 "
Si	126 kg. =	28 "
	460 kg.	

Cost of power $\$6.00 \times \frac{3}{4} \times \$0.75 =$	$3.37 per ton.
Other costs	10.00 "
Total costs per ton	$13.37

This cost is very low, because of the very low figure assumed for power costs. However, the whole calculation points to the possibility of great savings in some localities in smelting down copper ores by electrically applied heat, and the possibility of cheaply producing, at the same spot, valuable ferro-silicon as a by-product.

Physical Factors in the Metallurgical Reduction of Zinc Oxide.*

By Woolsey McA. Johnson.

Independently of the recognized chemical reactions involved in the production of metallic zinc, the process is affected by physical conditions in efficiency and by commercial as well as technical economy. To offer some observations concerning these conditions is the purpose of the present paper.

Among the important elements of this problem is the physical nature of the particles constituting the mass of zinc oxide to be reduced. This may be the result, either of the manner of the original deposition of the mineral, or of the treatment to which it has been subjected in the roasting furnace. The physical character of the reducing agent is another important factor, since the carbon of some coals is much more active in reduction than that of others. The degree of fineness, whether of ore or coal, or both, likewise plays a significant part. These factors, together with the physical admixture of foreign substances with the ore, may give rise also to chemical "side reactions," sometimes hindering or retarding and sometimes accelerating the reduction. Finally, thermal conditions, including the relative conductivity of the materials, deserve to be taken into account.

In firing a furnace with retorts charged with a mixture of roasted ore and coal, the first reaction is naturally the boiling off of the contained water; the next is the distillation of the light hydrocarbons from the coal; the next is the reduction of the iron oxide to protoxide and sub-oxide successively, and then to metallic sponge, and the final reaction is the reduction of the zinc oxide in the ore by the carbon to metallic zinc. This reaction commences at 1,022° to 1,060° C., according to the physical nature and condition of the coal and ore.

Since the retort and the charge are far from being good conductors of heat, we may assume that there exists in the charge a series of concentric hollow cylinders of gradually decreasing diameter, each hollow cylinder differing in temperature by a few degrees as the diameter grows smaller, the hottest part, of course, being the cylindrical layer next to the retort, and the coldest the core in the center of the charge. This is a convenient assumption for the purpose of illustration. In fact, such hollow cylinders do not exist separately, except as representing zones of temperature.

Now, with rapid firing, it is possible that the charge next to the retort walls may reach a temperature above that of the reduction of zinc, and, consequently, produce some zinc vapor, while in the center of the charge water is being boiled off. Obviously, this would be a bad way to fire the furnace, since the zinc-gas would be thereby so diluted that condensation would become practically impossible. The same evil thing occurs through the distillation of the hydrocarbons when too much light "gassy" coal is used. Diluting gas may similarly be formed from the reduction of the iron oxide when ores very high in iron are treated.

If we had an ideal charge, perfect in heat conductivity, it might be possible to keep all the contents of the retort at one temperature until the reaction requiring that temperature was complete; then immediately to elevate the temperature until the second reaction was complete, and so on, through the third and fourth reactions. This procedure would require, also, ideal conditions from a chemical standpoint, including a charge of such character that each of the several reactions would be practically complete at a temperature only three or four degrees above that at which it began. Such ideal theoretical conditions are beyond our reach, but may serve as a mental guide for formulating such conditions as are practically the best for any given situation as to ore and coal.

The firing of a zinc furnace for reducing ores high in iron should be done as follows: The furnace should be heated up to, and kept at, a temperature slightly below the reduction temperature of zinc, but as near that point as possible. This, in the course of an hour and a half or two hours will bring all the contents of the retorts to a uniform temperature of slightly below 1,020° C. Below this temperature the reduction of the iron oxide is largely completed. After this has been accomplished, the furnace should be fired for the reduction of zinc oxide.

If the reduction of the iron oxide and the reduction of the zinc oxide proceed simultaneously, the evolution of so much carbon monoxide and dioxide from the reduction of the iron oxide would sweep the zinc vapor through the condenser and burn it at the mouth. This is exactly what happens with too rapid firing. The bright, or so-called "angry" flame, burning the zinc with brilliant white fumes, while yielding practically no condensed metal, is the practical fact of which the above paragraphs are the explanation.

Through both special experiments and practical experience in zinc smelting I have found that the iron oxide has different degrees of reductivity, varying even more than that of zinc ores, according to the way they were originally deposited geologically and the way they have been roasted. This result corroborates the observations of Sir Lowthian Bell. A hard, dense zinc ore that is hard to roast, and gives a product not very porous, is naturally more difficult to reduce than one of a porous nature, which has been roasted at a low temperature. If, as sometimes happens, a zinc ore is roasted at such a temperature as to form an incipient slag, for example, an iron silicate, and also compounds of its different constituents, such as zinc ferrate, zinc silicate, zinc aluminate and lead silicate, the reduction of such an ore, so roasted, is retarded, its reductivity being decreased, because the compounds of zinc oxide are more difficult to break up than the oxide itself. Moreover, the particles are shrunk and cemented more closely together by the heat, just as a fire-brick, under the action of high heat, contracts and hardens, and their reductivity is thus decreased for physical reasons.

Thus it may be said that there are two kinds of work to be done in the reduction of zinc oxide. One is chemical work; the tearing of the atoms of zinc and oxygen away from each other against the force of affinity. The other is the work of tearing the molecules of zinc oxide from one another. This is physical work. Any agent that changes the aggregation of the molecules so as to make it denser increases the physical work to be done in reduction.

The formation of iron silicate in roasting is especially bad; for it is not easily reducible, and is itself a slag already formed, which will pick up other slag materials, and, collecting in the bottom of the charge, quickly cut a hole through the retort. For this reason several zinc plants in Kansas charge carbonates "green" into the retort, even though their bulk is greater.

Metallic iron as an iron sponge does not, in my opinion, have very deleterious effects, provided sufficient fine clean coal is present. In the first place, the iron seems to draw up in globules in the pores of the charge by capillary attraction, and to be held there as water is held by a sponge. Not only is its melting point high but it has no great chances to form alloys with other metals.

The iron sulphide, on the contrary, is really the most corrosive part of a charge, whether present in the charge as pyrites in the original coal or pyrites not roasted in the ore, or formed by the iron sponge acting on the zinc sulphide. At from 1,100° to 1,200° C. iron sulphide will dissolve fire-clay practically as hot water dissolves sugar. Several times, in my small electric crucible furnace, I have added pieces of a retort to molten iron sulphide, and observed a considerable evolution of sulphur dioxide, suggesting that an iron silicate formed. This product analyzes 3 or 4 per cent S and is partially a sulpho-silicate.

Moreover, molten iron sulphide is extremely mobile and will

* A paper read before the American Institute of Mining Engineers at the Toronto meeting. (Bi-monthly Bulletin No. 17.)

penetrate the pores of a retort, where it forms, under the oxidizing flames of the combustion gases, an iron slag, and cuts a hole through the retort. Then the metallic iron in the charge is oxidized and furnishes enough iron oxide for the formation of more slag. In the course of four or five days, if slagging has happened first on a retort in the top row, all the retorts vertically under the unfortunate one will be cut out and spoiled by the slag dropping down from it. The whole trouble is probably caused by an accidental and local excess of iron sulphide in one portion of the charge, due to poor roasting or poor coal, or both, and an uneven "mix."

A phenomenon of zinc smelting which puzzled me for a long time is what is known as the "setting" of the furnace. When a furnace is fired up so rapidly at first that a great deal of zinc cannot be condensed but burns at the mouth of the condenser, the furnace-man will often suddenly reduce the temperature to stop this loss of zinc. If this change be too marked, the charge in the furnace becomes "set," and it is impossible to get the zinc out, even though the temperature be raised to a point much above that ordinarily employed. The reason is that a thick, heavy slag is thus formed, and, once formed, contracts on cooling, and encircles the particles of ore and coal. If the temperature had been brought up slowly the slag would never have been formed, or would have been formed only at the end of the shift, when the charge was "dry" of zinc.

This suggests another point. While a thick slag prevents reduction the formation of a very liquid slag facilitates it, probably by bringing the reacting substances into igneous solution, so that they can act on each other. In American zinc practice it is deemed inadvisable to form slag at any time if it be possible to prevent it, but in Europe, occasionally, the residues are tapped from the retorts as a liquid slag.

This brings us to the essential difference between European and American zinc furnace practice. By a sort of natural evolution the practice of each country has tended along the lines suited to the commercial environment. In Europe, coal is expensive and labor cheap. In the United States, gas and coal are very cheap, labor is dear, and our workmen have not had the training in zinc smelting of those in Germany and Belgium, where this calling has often been followed in the same family for three or four generations.

Consequently, the practices are radically different. The German metallurgist charges a small amount of coal, with a roasted zinc ore averaging something under 50 per cent of zinc, into muffles holding 80 to 100 pounds of ore. This is fired in regenerative furnaces with great care. At the end of the shift the residues are carefully scratched up by hand, sometimes without taking the condenser down, and the retorts are sometimes charged again through the mouth of the condenser. A great deal of labor is always used per retort.

In the United States the retorts are cylindrical and are charged very rapidly with a material high (in the case of Joplin ores over 70 per cent) in zinc. The furnaces are fired very extravagantly, usually with natural gas. At the end of the shift the residues are blown out by steam or water. In Kansas the aim is always to make a charge that contains so much coal and so little iron sulphide as to be non-corrosive, and leave "dry" residue—one that contains a minimum of slag. Very little scratching or cleaning of the retorts by hand-rabbling is done in this country. It will be seen that the practice of Europe and of America is different in these respects, by reason of totally unlike conditions in the two regions.

In the treating of ferruginous zinc ores from Leadville and elsewhere, American practice has been simply a refinement and a carrying out to the extreme of the method pursued with Joplin ores. The attempt is always to make a non-corrosive charge which, by reason of its large amount of fixed carbon, will also have a maximum reductivity at as low a temperature as possible. The criterion of this charge for low-grade ores is recognized by the practical zinc smelter in the glowing and brightening up of the residues when the condensers are "knocked down" in the morning at the end of the shift. If the residues then glow, it is, of course, a sign of the presence of active particles of carbon, to be attacked by the oxygen of the air which rushes into the retort. Consequently, the charge at the end of the shift still possessed considerable reductivity, and it was not necessary to use intense heat to reduce and distill the zinc. Did the charge contain no remaining active carbon it would not glow. The zinc smelters have almost a superstition about this glowing or "looking red" in the retort; and it is convincing to see that it has good chemical reasons.

Another fact about zinc reduction which I have never seen noticed, is that carbon deposition occurs around the iron oxide just as it does in the shaft of an iron blast furnace, and that this deposited carbon is very active in reducing the particles of zinc oxide.

The reaction of the iron-sponge on both zinc oxide and zinc sulphide increases, of course, the amount of zinc distilled. These reactions are both completed below 1,200° C. The iron is formed as an iron-sponge through the reduction of the iron oxide by the carbon of the charge. For this reason magnetic zinc blende, the so-called "marmatite," is very active.

Another characteristic of the reduction of zinc oxide is the distillation of the heavy tars in the coal. These heavy tars are distilled at about the temperature at which zinc is reduced, and are retained in the condenser, where they form a solid mass and in time choke the condenser. I have never seen this reason given before; but it is undoubtedly the chief reason why accretions are slowly formed on the sides of the condensers, which have to be cleaned out by the "connie boy."

The coal for a zinc charge should have maximum heat conductivity, "reductivity" (*i. e.*, active energy in reduction), and percentage of fixed carbon per cubic foot; and minimum proportion of hydrocarbons and of ash (the ash containing, moreover, a maximum of aluminium silicate). Finally, it should be low in price.

To combine all these good qualities in one kind of coal is impossible, and hence it is advisable to use three or four different kinds, one serving one purpose and another another. For instance, petroleum coke, the residue from the distillation of oil, contains from 94 to 96 per cent of carbon, and less than 1 per cent of ash; but it carries 3 or 4 per cent of heavy hydrocarbons. This would be an ideal reducing agent for zinc, did not its hydrocarbons choke up the condenser; and therefore it should not be used for more than one-sixth of the total fuel.

"Dead coal," from the "strip pits" of Missouri and Kansas, has carbon of good activity. The ash is also pretty infusible, because the sulphur has been extracted through weathering of the coal. It yields, however, a very high amount of gas, and therefore too much of it should not be used. Moreover, it is always well to use several kinds of coal, so that accidental poor shipments of one kind will be "averaged out."

All things considered, probably the best reducer for a zinc charge is anthracite slack, having less than 0.6 per cent sulphur and an ash which is nearly an aluminium silicate. It is, however, usually too expensive for use except in a few localities.

For maximum reductivity, neither the zinc ore nor the reducing material should be too fine. With coal and ore finer than 60-mesh, there will be channeling of the gases of reduction, and the very efficient reducing action of hydrocarbon vapors and carbon monoxide will be lessened. Besides, there is a "back pressure" of these gases, which retards reduction.

The ideal of American zinc practice should be to produce a charge of maximum reductivity with an infusible residue. If this were attained it might be possible to use much larger retorts, or possibly a gas-fired continuous furnace.

In this paper the word "reductivity" has been applied to the charge, the reducing agent and the ore, while possibly a stricter phraseology should have been used.

In conclusion, I want to express my appreciation of Dr. Percy's early work on zinc. Having repeated and extended all his experiments, I feel bound to testify that they reached the heart of the subject, and established principles not superseded by later progress. This is not true of all such pioneer work, however creditable it may have been in its day; and when it is true it deserves to be publicly declared.

I wish, also to acknowledge my indebtedness for valuable suggestions to Messrs. C. A. H. de Saulles, John Nett, Walter J. Chapman and many others.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron.

By Baron von Jüptner.

(*Continued from page 440.*)

II.

For the calculation of the tensions of dissociation at any desired temperatures we can make use of the approximation formula established by Nernst.[1] Fig. 1 gives the logarithms of these dissociation pressures thus obtained. Fig. 2 these pressures themselves for a series of iron and manganese oxides between 600° and 2,400° absolute. In Fig. 1, curve 1

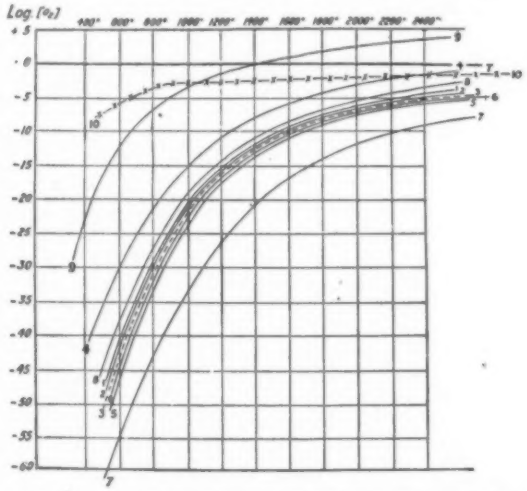


FIG. 1.—LOGARITHMS OF THE TENSIONS OF DISSOCIATION OF SOME OXIDES ACCORDING TO NERNST'S APPROXIMATION FORMULAE.

refers to $2FeO = 2Fe + O_2$, curve 2 to $2Fe_2O_3 = 4Fe + 3O_2$, curve 3 to $2Fe_2O_3 = 4FeO + O_2$, curve 4 to $6Fe_2O_3 = 4Fe_3O_4 + O_2$, curve 5 to $2Fe_3O_4 = 6FeO + O_2$, curve 6 to $Fe_3O_4 = 3Fe + 2O_2$, curve 7 to $2MnO = 2Mn + O_2$, curve 8 to $MnO_2 = Mn + O_2$, curve 9 to $2MnO_2 = 2MnO + O_2$, curve 10 to $Fe_3O_4 = Fe_2O_3 + FeO$. A comparison of these two figures shows that, for graphic representation, the logarithm serves far better than the pressure itself, since in Fig. 2 only three of the ten curves contained in Fig. 1 could be represented.

It must be mentioned that these curves can only be applied to the case in which the dissociation heats are independent of the temperature, which nearly happens for the dissociation of iron oxide $Fe_2O_3 = 2Fe + 3O$, since the heat of formation of this compound is at

	Calories.
1,000° C.	195,600
400° C.	197,700

so that 600° difference in temperature only alters their value by about 1 per cent.

[1] Göttinger Nachrichten, 1906.

Although the curves above mentioned can only be looked upon as approximations, yet they enable us to learn many things. An oxide will be decomposed so much the easier, the greater is its tension of dissociation.

Thus iron oxide gives off oxygen fairly readily at a white heat, and is transformed into Fe_3O_4. On the contrary, the decomposition of Fe_3O_4 into metal and oxygen is more difficult than that of FeO, which agrees with the experience obtained in the blast furnace. Consequently the reduction of Fe_3O_4 into FeO takes place first, and later that of FeO into Fe.

The tension of dissociation of Fe_2O_3 when completely decomposed is larger than that of the simultaneous formation of FeO. There is, therefore, not an immediate reduction to metal, but FeO must first be formed. The same is the case exactly with Fe_3O_4.

MnO_2 is reduced more readily to MnO than to Mn. This arises from the fact that the tension of dissociation of MnO is exceedingly small. Further, if the MnO_2 be decomposed into Mn and O_2, the oxygen thus set free must immediately oxidize the metallic Mn into MnO.

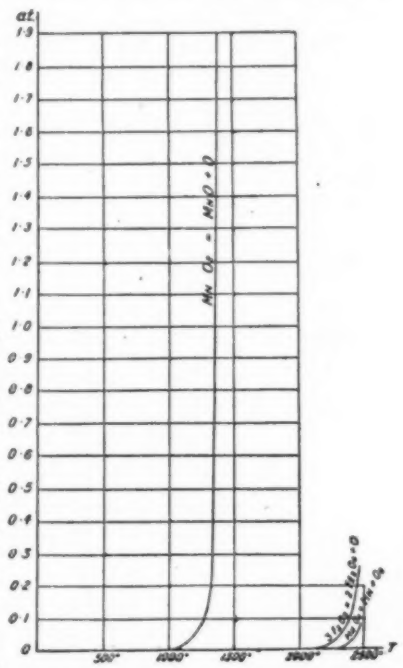


FIG. 2.—DISSOCIATION PRESSURE OF SOME OXIDES AT CONSTANT VOLUME.

The above curves also show that MnO_2 gives up oxygen more readily than iron oxide, but that inversely metallic Mn must be able to reduce iron oxide to metal, which agrees with our experience.

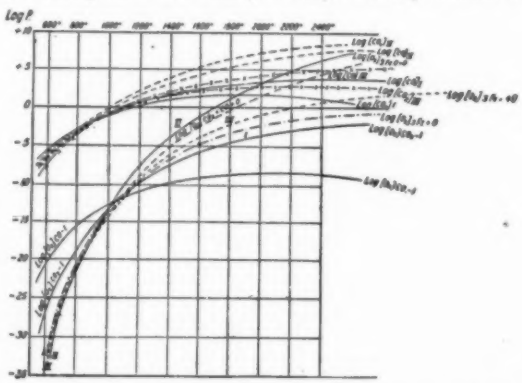


FIG. 5.—LOGARITHMS OF THE TENSIONS OF DISSOCIATION OF $FeO = Fe + O$; $Fe_3O_4 = 3FeO + O$; $Fe_2O_3 = 3Fe + 2O_2$; of CO and CO_2, AS WELL AS THE PARTIAL PRESSURE OF [CO] AND [CO_2] FOR CONSTANT PRESSURE.

It has been shown by Tholander that at a white heat in air, Fe_2O_3 gives off oxygen, and is changed into Fe_3O_4. The tension of dissociation, therefore, of the former must be greater at this temperature than the oxygen pressure of the atmos-

phere (0.21 atmosphere). According to our curve, both are equally great at about 2,300° absolute (2,030° C.). This agrees quite well qualitatively with this experience. Quantitatively, however, the agreement is less good, since according to White and Taylor's determination, a white heat commences at about 1,200° C.

From the beautiful experiments of Bauer and Glässner, as from those of Schenk and Heller, for some oxides of iron the relation between the tension of dissociation and temperature can be fixed nearer than is possible by the above approximation equations.

We thus arrive at the curves given in Fig. 2. These curves ought really to be considered trustworthy only up to about 1,600° absolute, since the experiments upon which they were founded only extended to about 1,200° absolute, so that further extra-polation must be regarded as somewhat risky.

With the oxides hitherto considered, we have been dealing with bodies, which, upon dissociation, do not themselves pass

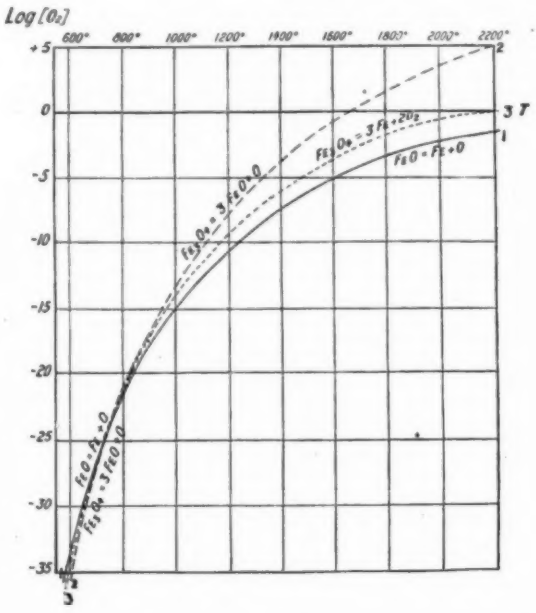


FIG. 3.—LOGARITHMS OF THE TENSION OF DISSOCIATION REACTIONS
$FeO = Fe + O$; $Fe_3O_4 = 3FeO + O$, and $Fe_3O_4 = 3Fe + 2O_2$ FOR CONSTANT VOLUMES (CALCULATED BY MEANS OF THE APPROXIMATION FORMULA).

into the gaseous state. Before we can enter upon the reduction of iron oxides we must deal with the dissociation of gaseous bodies.

As known, N_2O_4 decomposes according to the equation $N_2O_4 = 2NO_2$.

The dissociation stops when a given pressure of NO_2, that is, when a certain tension of dissociation is reached. But whilst, in the cases hitherto considered, this tension of dissociation was only dependent upon the temperature, it is here dependent also on the pressure of the simultaneously present still undecomposed N_2O_4 residue. As limit to the dissociation, we have then the expression

$$2 \log [NO_2] - \log [N_2O_4] = K.$$

We can say, generally, *that the dissociation of gas-forming bodies comes to an end when the sum of the logarithms of the pressure exerted by the decomposition products (taken in the earlier sense) is as great as the logarithm of the pressure of the yet undecomposed residue of the dissociating body, plus the constant K.*

Now, since carbon, carbonic oxide and hydrogen come chiefly into question in metallurgical reduction processes, we must, first of all, learn the tension of dissociation of CO, CO_2, and H_2O.

The logarithm of the oxygen pressure of $CO = C + O$; $CO_2 = C + O_2$; $CO_2 = CO + O$; and of $H_2O = H_2 + O$ are graphically represented in Fig 4, for the case that the partial pressure of CO. CO_2 and H_2O are 1 atmosphere, since from this the value for other pressures is easily arrived at. With the help of these curves it is easy to study the reactions which come into play on the burning of coal with oxygen, as well as the production of producer gas, water gas, and mixed gas. But we will here confine ourselves to the reactions between iron and its oxides, on the one hand, and carbon, hydrogen, carbonic oxide, carbonic acid, and water.

Since for the oxides at a given temperature there is a certain fixed oxygen tension, a fixed equilibrium pressure of H_2O, CO and CO_2 for this change of action must also exist; a fact which has already been pointed out by Schenk. This equilibrium pressure can be directly derived from the curves of Fig. 5. But if these partial pressures of the reacting ma-

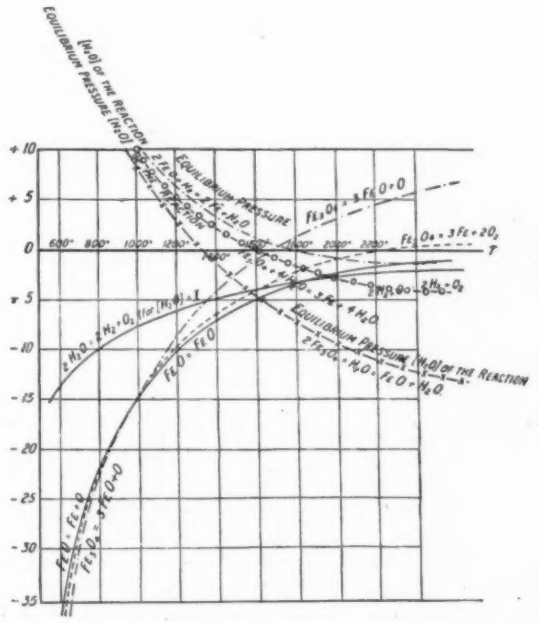


FIG. 4.—DISSOCIATION PRESSURE AND EQUILIBRIUM VAPOR-PRESSURE OF THE VAPOR OF WATER AND OF IRON OXIDES AT CONSTANT PRESSURE.

terials, in reference to the reaction products, are fixed, on the one hand, by the tension of dissociation of the oxides in question, so also must the rates between CO and CO_2 (which appear invariably together) for a given oxide for that temperature be a fixed one.

In Fig. 6 this is represented, as it is calculated, on the one hand, theoretically, and also as Bauer and Glässner have experimentally determined it.

In general both values agree well together, but at lower temperatures the Bauer curves show breaks which can be put down to the formation of more stable oxides. Thus, at lower temperatures the tension of dissociation of the FeO is greater than that of Fe_3O_4. A conversion of the former into the latter is therefore more likely, if the gas pressure is a proportionate one. For then the experiment must give results which approximate to the decomposition $Fe_3O_4 = 3Fe + 2O_2$, which is actually the case. But it is possible also that even more

stable oxides of iron exist, of which there are many indications.

[The concluding part of Prof. von Jüptner's paper will be

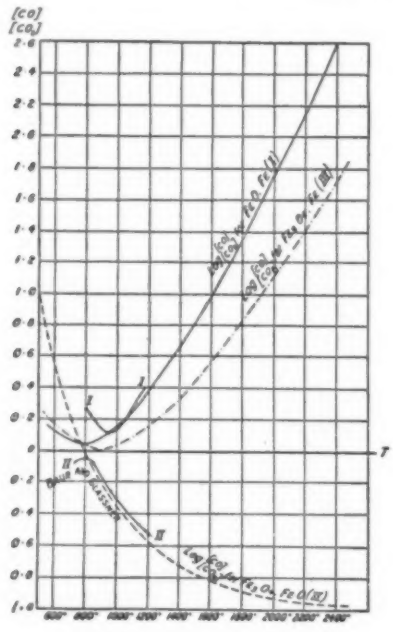


FIG. 6.—LOG $\frac{[CO]}{[CO_2]}$ FOR THE SYSTEMS CONSIDERED.

published in our next issue. It deals with the application of the above principles to the consideration of blast-furnace practice.]

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

An Electrochemical Exhibit at the Engineering Exhibition.

The Engineering Exhibition at Olympia this autumn is mainly a machine tool exhibition, and metallurgical developments are only emphasized by machines for dealing with the finished product of the iron and steel maker. One exhibit of an electrochemical nature may be chronicled. This was Messrs. J. Defries & Son's "Meridionizer Cell," for the production of hypochlorites. This firm have acquired the Digby patents for the United Kingdom. The method employed is that of a double diaphragm cell with porous diaphragms closely surrounding both anode and cathode, and the anolyte and catholyte kept out of contact with the main body of the electrolyte. Fresh water containing a little alkali or a little sodium chloride (to reduce its resistance) is run into the cathode compartment, and there combines with the liberated sodium to form a solution of sodium hydrate. The cathode liquor then passes through a special passage to the anode compartment, where, coming in contact with the nascent chlorine there liberated, forms a solution of sodium hypochlorite. In this process the proportion of unconverted sodium chloride in the resultant hypochlorite liquor is lower than in any other apparatus. The combined costs also are lower than those claimed for any other method. Acheson graphite is employed for both anode and cathode.

A Rehabilitation of the Large Gas Engine.

After the failure of the big gas engines at Johannesburg, large gas engines employing either producer gas or the waste gases from blast furnaces have been rather under a cloud. The troubles have been numerous, and the whispered, but unwritten, history of the large gas engine is vastly more portentious than the written history. All this is a great pity, for it is of prime importance that the large gas engine should prove its capabilities beyond any question, as so much can be done in large iron and steel works by the supply of electricity from a local power house where large internal combustion engines utilize the waste furnace and coke oven gases.

This month there has been a pilgrimage from London to South Germany of a specially invited party of electrical engineers and representatives of the technical press. They saw a large number of installations erected by their hosts, Messrs. Ehrhardt and Sehmer, of Saarbrucken, which embraced engines driving alternating-current generators, blowing engines and direct-current generators.

Germany certainly seems to have given both Great Britain and the United States a big lead in this branch of engineering. Very good evidence of this is given in a paper recently read by Mr. F. Sellge before the German Iron & Steel Works Society, on the difficulties met with in the working of large gas engines and methods of overcoming them, which contains an interesting statement as to the working results obtained at the Differdinger Iron & Steel Works, of which Mr. Sellge is the gas-engine manager. Before the introduction of gas power the amount of coal consumed for generating steam was 5,300 tons per month, the output of pig iron in the same period being 21,400 tons, of which 70 to 80 per cent was converted into steel and rolled, while the remainder was turned out as billets. The cost of coal at 18s. per ton was £4,770, or 4.46s. per ton of pig iron. When gas engines were installed the coal consumption diminished to about 500 tons per month, costing £450, while the output of iron has increased to 30,000 tons per month, the cost of fuel for power being therefore reduced to 0.3s. per ton of iron; assuming that under the former conditions with steam power the cost of fuel would have increased in proportion to the output of iron, the saving amounts to 4.16s. per ton, equal to £6,240 per month, or about £75,000 per annum.

Electric Pumping at Lindal Moor Mines.

A very interesting and comprehensive electrical pumping installation has been inaugurated this month at the Iron Ore Mines at Lindal Moor, where certain mines had been derelict for three years owing to the inrush of water. The following particulars of the installation are perhaps not out of place in this letter, as if the iron ore famine, regarded as inevitable by some leading metallurgists, is to be deferred, this postponement of an evil day can only be achieved by utilizing every advance of science in the battle with the forces of nature.

In the Lowfield pit, which is inclined at an angle of 43° to the vertical, two centrifugal pumping sets have been provided, each capable of delivering 4,000 gallons of water per minute against a total head, including friction, of 395 feet. On reaching a depth of 378 feet, where the two shafts join, these two pumps will be connected in series, and the design is such that when working in series they can together deliver the full quantity of 4,000 gallons per minute against a total head of 780 feet. These two pumps are of the one-stage type, and rest upon a special carriage running on rails having a gauge of 6 feet 6 inches.

Each pump has two wrought-iron delivery pipes, which are connected at the top by means of a Y pipe, which supports a rising main 14 inches in diameter. The check valve has an internal diameter of 375 mm. and a foot valve of 450 mm. internal diameter is fitted with strainer. Each

pump has a rope sheave 4 feet in diameter mounted on suitable brackets. Each of the motors direct coupled to these two pumps is capable of a continuous output of 750 b. h. p. when working on a circuit of 3,000 volts 50 cycles per second, and the speed of the combined set is 1,485 r. p. m.

In the Diamond shafts two vertical sinking pumps are provided, each of which is capable of raising 1,000 gallons of water per minute against a total head, including suction, delivery and pipe resistance, of 680 feet. These pumps are also fitted with direct-coupled motors having an output of 315 hp. at 1,480 r. p. m. These pumps are of the three-stage type, and are fitted with elastic couplings and cast iron intermediate piece for connecting and centering the pumps with the motors. A breeches pipe is provided in each case, with wrought iron suction pipe 230 mm. internal diameter, foot valve and strainer; also two wrought iron delivery pipes connected at the top by a Y pipe, which supports the rising main. Each set is complete with check valve, by-pass and gate valve 225 mm. diameter.

In the Bercune pit are provided two pumping plants of similar design to those in the Diamond pit; but in this case each pump is designed for delivering 1,000 gallons of water per minute against a total head of 540 feet, the motors having an output of 250 hp., and the speed of each set being 250 r. p. m. These pumps are each of the five-stage type. The arrangement of valves and pipes is the same as for the Diamond pumps.

A three-phase alternating-current system has been adopted, and in order to transmit the required power without undue loss, and at the same time have a working pressure which could be used direct in the motors without transformers, a pressure of 3,300 volts, with a frequency of 50 cycles per second, was chosen.

The current is generated by three steam turbo-generators of the horizontal type, designed and constructed on the A. E. G. principle, each set being capable of a continuous output of 1,140 E. hp. when running at 3,000 r. p. m. and supplied with steam having a pressure of 200 pounds per square inch at the top valve, superheated to a temperature of about 600° F. Each turbine exhausts into a surface condenser of Messrs. Worthington's manufacture, specially designed for maintaining the high vacuum which is necessary for the efficient working of turbine plant. A special description of the A. E. G. turbines appeared in *The Electrician* of Dec. 14, 1906, and it will be remembered that they are designed on the velocity principle, steam being expanded and its pressure energy transformed into velocity energy in two stages, each pressure stage having two velocity stages.

The generators are of a particularly solid construction, the rotating field possessing the characteristic of a solid cylinder. By a special system of ventilation and by water circulation in a double casting round the stator and bearings, the entire generator is kept particularly cool. The circulating water flows by gravity under a head of about 20 feet from a tank situated above the engine room. The amount of water specified to be taken by each generator is 11 gallons per minute, but the amount can be regulated as required. This arrangement of water circulation is exceedingly simple, and the generator is kept perfectly cool, which is not always the case in turbine machines. The generator also runs practically noiselessly, owing to the construction of the stator, which does away with the noise often set up by the ventilating discs existing in other types of plant.

A special feature of the control arrangements is that each of the six pit motors is individually under the control of the power station engineer, the whole of the starting and stopping operations being carried out by means of the switchboard apparatus.

Two sets of bus bars are provided, one set for running the motors under full pressure, and the other for gradually raising the pressure at starting. The starting is effected by means of two transformers connected in series. One of these is an auto-transformer, which reduces the voltage to about half the working pressure; the second transformer has its primary connected in series with the auto-transformer, and its secondary connected to the liquid resistance, which is gradually short-circuited on starting the motors. By this means the pressure on the motors is increased gradually, and all large current rushes, which might in the ordinary way affect the voltage regulation of the station, are avoided. As soon as the motors have been run up to full speed on the auxiliary bus bars they are switched onto the main bars by means of change-over switches of the oil-break pattern.

ELECTRICITY IN ROLLING MILLS

That our electric power supply companies are alive to the probable demands of this section of our manufacturing centers is clearly indicated from the following extract from the speech of the chairman of the Cleveland & Durham Electric Power Co., Ltd., at the annual meeting of the shareholders:

"It was no exaggeration to say that recent advances in this connection represented the most important development in the application of electricity to motive power purposes that had taken place during the last five years. This was much to say, in view of the fact that the applications of electricity in other directions had been so important, but a consideration of the magnitude of the iron industry in this and other countries more than justified the assertion. It now appeared certain that electricity would replace steam for all rolling-mill work, the lightest as well as the heaviest, and this, too, in the course of the next few years. As the Cleveland district produced between a quarter and a half of the iron of the United Kingdom, this development would eventually have an extensive and very favorable bearing on their company's progress."

THE FINANCES OF THE ELECTROLYTIC ALKALI CO., LTD.

The directors' report for the year ended Aug. 31 states that the net profits for the year, after allowing for depreciation, mortgage debenture interest and expenditure on renewals, repairs and general upkeep of buildings, plant, machinery, tools, etc., is £8,212 plus £2,127 brought forward, making a total of £10,339. The hope expressed in the last annual report that further developments during the ensuing year would show better results has not been realized. The causes of this result have been entirely beyond the control of the board, the further increase during the year in the price of fuel, packages and other commodities which form the chief items of cost of the company's manufactures being mainly responsible for the decreased profit. The market prices of the company's products are abnormally low compared with those of other heavy chemicals, and the company has not participated in the advanced prices which were obtained during the period in other branches of their trade. Notwithstanding the result now shown, the directors have the fullest confidence that when normal prices have been reestablished the company will be able to make a satisfactory return to all the shareholders. Two and a half years' dividend on the preference capital has now accrued; but in view of the unsettled state in that portion of the chemical trade in which the company is engaged the directors think the wisest course is to pay only one-half year's dividend upon such shares; £6,840 is to be carried forward. The erection of the additional plant is nearing completion. It has not been possible to get any benefit from this during the past year, while the expense of issuing debentures needed to pay for such plant and the interest on them have been charged against revenue. The same rates of depreciation as in past years have been maintained, and an increased amount for renewals and repairs necessary to keep the buildings, plant, machinery and tools in a high state of efficiency, is also charged against the

year's revenue. The demand for the products of the company is eminently satisfactory. The directors hope to have the new installation in operation at an early date, when they will be in a better position to deal with the increased volume of business which has already been secured.

Market Prices During October.

The price of bleaching powder at the end of October was, for 35 per cent, £4.7.6 per ton. Caustic soda, 77 per cent, £11.2.6.; ammonia sulphate, £12.0.5, and copper sulphate, £22.10. Shellac was £11 per cwt.

Regarding the metal prices: Copper opened at £63.5 per ton, and, after falling to £61.10 on Oct. 3, rose to £64 on the 7th; then followed a continuous fall to £55.10 on the 23d, with the exception of a slight rally on the 15th. From the 23d to the end of the month a sharp rise occurred, £62 being reached on the 28th.

Cleveland pig iron was 55s. per ton on Oct. 1; it fell to 54s. 3d. on the 2d; and, rising to 55s. 10d. on the 7th, fell to 54s. 4d. on the 10th; a rise to 55s. 3d. occurred on the 11, followed by a fall to 53s. 8d. on the 15th, and continuing fairly steady until the end of the month, closing at 54s.

Hematite fell almost continuously during the month, opening at 75s. 6d. it remained steady at 73s. 10d. from the 8th until the 11th; fell to 73s. on the 14th, at which price it remained with the exception of a slight fall to 72s.10d. on the 17th, until the 18th, then falling to the closing price of 71s.

English lead also fell continuously during October, opening at £21.15 to £22, and closing at £18.15 to £19.

London, November, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS

Electric Furnaces.

Resistor for Electric Furnace.—Frank J. Tone, 870,326, Nov. 5, 1907. Application filed March 7, 1905.

A "self-sustaining resistance conductor" is obtained by putting together a series of regularly shaped blocks in form of a vertical or horizontal column. The resistance of this resistor is the sum of the resistances of the carbon blocks themselves and of the contact surfaces. By making the number of contact surfaces large in proportion to the linear dimension of the resistor in the direction of the current a high resistance can be obtained. By using a continuous rod it would become necessary to make the resistor much longer and thinner, while by assembling a number of carbon blocks together greater mechanical strength can be obtained.

Electric Furnace.—P. L. T. Héroult, 871,273, Nov. 19. 1907. Application filed May 3, 1907. Assigned to Société Electrometallurgique Française.

For regulation of the power supplied to an electric furnace, without moving the electrodes themselves, a false or dummy electrode is employed. By varying the position of this false electrode, which is of greater conductivity than the material of the charge, the total resistance to the passage of the current between the two electrodes is varied. This false electrode may be easily shifted, since it does not require any electrical connections or sliding stuffing-boxes, etc. In Fig. 1 the hearth A forms one electrode and the ring C of carbon at the top the other electrode, while E is the false or dummy electrode, consisting of a stick of carbon and adjustable in its vertical position.

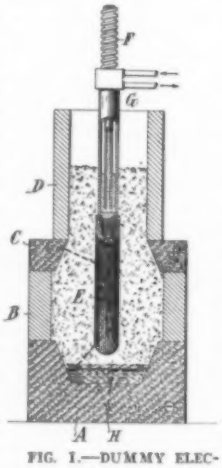


FIG. 1.—DUMMY ELECTRODE FOR ELECTRIC FURNACE.

Electric Furnace.—P. L. T. Héroult, 871,338, Nov. 19, 1907. Application filed April 21, 1906. Assigned to Société Electrometallurgique Française.

For the purposes explained in our Vol. IV., page 152. a hollow carbon electrode is used, the fuel for reduction being introduced through the electrode separately from the ore. The electrode is held by a stuffing-box of copper, which is internally cooled by water or air and serves at the same time for making electric connection, the usual cable box being bolted to a projection of the stuffing-box. The electrode slides downward through the stuffing-box as its lower end is consumed, and it is important to obtain a good contact between the stuffing-box and the electrode. For this purpose divided rings of conducting material are employed which surround the electrode, the adjacent rings having contact surfaces which are wedge-shaped so that the pressing of them together not only makes a more intimate contact between them but also makes a more intimate contact of one of the rings with the electrode.

Carbon Tetrachloride.—Fred. J. Maywald, 870,518, Nov. 5, 1907. Application filed Oct. 6, 1902.

A furnace with two carbon electrodes is filled with lumps or nodules of coke, preferably of the size of a hickory nut, and by passing the electric current through the mass the coke is brought to incandescence. When a stream of chlorine gas is then passed through the furnace it is said to combine with the incandescent carbon in the proper molecular proportions to form carbon tetrachloride CCl_4.

Electrolytic Processes.

Lead-White and Lead-Chromate by Electrolysis.—E. D. Chaplin, 871,161 and 871,162, Nov. 19, 1907. Applications filed Feb. 3, 1906. Assigned to International Lead Cos.

Patent 871.161 refers to the electrolytic production of lead-white. A solution of sodium nitrate and sodium chlorate is supplied to the middle compartment of a three-compartment electrolytic cell, and the level of the solution is maintained higher in the middle compartment than in anode or cathode compartments, so as to prevent mixing of the anolyte and catholyte. The anode is made of lead and the cathode of copper. The product at the cathode is sodium hydrate, while at the anode lead-nitrate is probably first formed, which is then converted into lead-oxychloride, which is soluble at the elevated temperature at which the electrolyte is maintained by means of a steam coil. The lead-oxychloride being an acid salt of lead renders impossible the formation of insoluble basic salts of lead. The sodium hydrate is converted in a separate tank into sodium carbonate by the action of carbon dioxide, and the sodium carbonate is then mixed with the lead-oxychloride, converting the latter into lead carbonate. The latter is collected by filtration while the filtrate is substantially the original electrolyte and is used over again.

Patent 871,162 refers to the production of lead-chromate. The first part of the process is the same as in the preceding patent. The lead-oxychloride is converted to lead chromate by treating it with a mixture of sodium chromate and bichromate. To produce the latter the sodium hydrate, produced in the electrolytic cell, is made use of. It is mixed with a solution of chromate alum. By producing an excess of sodium hydrate, chrome hydrate is precipitated and redissolved. It is mixed with sodimum chloride and subjected to electrolysis,

whereby a mixture of sodium chromate and bichromate is produced.

Arsenic Compounds of Lead.—Cornelius D. Vreeland, 870,915, Nov. 12, 1907. Application filed Feb. 5, 1906.

A series of lead anodes are placed in a cell filled with a solution of sodium nitrate. Between every two succeeding anodes a porous cup is placed containing sodium hydroxide solution and an iron cathode. The action of the current is the formation of lead nitrate at the anode while at the cathode sodium hydroxide is reformed and hydrogen is given off. During electrolysis a solution of a sodium salt of arsenic, for example, sodium arsenate, is introducted continuously into the anode compartment in just the proper quantity to react with the lead nitrate formed, yielding lead arsenate and sodium nitrate. The lead arsenate being a heavy insoluble substance, is precipitated out of the solution and settles to the bottom of the vessel, whence it can be drawn off in any suitable manner. The first claim refers broadly to "the process of manufacturing arsenic compounds of lead, which consists of the formation of a soluble salt of lead by electrolysis in the presence of a soluble compound of arsenic and the simultaneous precipitation of the lead thereby as an arsenic compound of lead."

Plating Device.—G. W. Clough, 870,545, Nov. 12, 1907. Application filed Oct. 10, 1906.

For electroplating heavy articles, a rocking receptacle is provided by means of which the articles are forced to roll or tumble about so as to be plated on all sides. It is a trough with an angular bottom, an angle of 45° or more being most convenient. A curved bottom may also be used. The cathode consists of metallic strips in the sides of the trough, which are connected to conducting bars at the top of the trough.

Apparatus for Electrochemical Analysis.—G. A. Guess and H. E. T. Haultain, 870,674, Nov. 12, 1907. Application filed April 26, 1906.

The invention comprises essentially a bench of adjustable beaker stands. in connection with a series of terminals in sets of three supplied with electrodes and connected up in circuit in various ways. They are adapted to be short circuited so as to cut out any particular assay or vary the current flowing through it without effecting the others.

Electrode.—G. A. Guess and H. E. T. Haultain, 870,675, Nov. 12, 1907. Application filed April 26, 1905.

A light and cheap electrode for electrochemical analysis consists of a thin platinum sheet, having a blade corrugated lengthwise, to render it rigid and a tang or shank adopted to be frictionally engaged in a slitted terminal or binding post. Only the blade is immersed in the electrolyte. With three electrodes placed equidistant, the two outer ones being anodes and having comparatively narrow blades, a uniform deposit is obtained on the middle electrode which is the cathode.

Carbon Electrode.—W. Möllenbruck and W. Dielmann, 870,985, Nov. 12, 1907. Application filed Oct. 23, 1906.

The electrode consists of a number of carbon rods circularly grouped or of an ordinary carbon cylinder or of a cylinder composed of lead carbon rings placed one on top of another, a central cavity being thus formed from end to end. Within this cavity a removable but snugly fitting carbon rod is placed protruding from the cell. This is the only movable part, and in case of breakage it can be easily renewed.

Reducing Formic Acid.—Carleton Ellis and K. P. McElroy, 867,575, Oct. 8, 1907. Application filed May 2, 1907.

The object is to reduce formic acid to produce methyl alcohol formaldehyde and condensation products. This is done by electrolysis in the presence of a strongly dissociated acid; a 10 per cent solution of sulphuric acid is said to be suitable. The electrolysis is carried out in a diaphragm cell, the formic acid being added to the sulphuric acid in the cathode department. The reduction of the formic acid is thought to be secondary and due to the H ions set free at the cathode. Two main reactions are possible: a replacement of the saturating oxygen of the carboxyl by hydrogen with formation of methyl alcohol or a replacement of the hydroxyl by hydrogen forming formaldehyde. A low-current density favors the formation of formaldehyde, while a high-current density gives a greater proportion of methyl alcohol. Lead cathodes or spongy nickel-iron or cobalt cathodes are advantageous. The presence of a catalytic agent, such as cerium salts, is advantageous. When the acid liquid is withdrawn from the cathode compartment, the methyl alcohol and formaldehyde formed are distilled out and thereby shielded from further reduction and the acid is returned to the cell for further use.

BATTERIES.

Storage Battery.—J. C. Cook and E. Sokal, 870,015, Nov. 5, 1907. Application filed May 10, 1905.

The plate represents a combination of Plante and Brush formation. A lead plate is provided with numerous closely-arranged spurs, pins or projections about half an inch long. so that the surface has a brush-like appearance. Over the surface of the plate and around the base portions of the spurs or equivalent projections, a paste is applied as in ordinary Brush plates, while the large superficial area of lead is constituted by the exposed portions of the projections is subjected to the Plante action in service. The layer of paste should be of sufficient thickness to give the plate a suitable capacity. A considerable portion of the projections extends into the electrolyte, and by charging and discharging in clear dilute sulphuric acid the same are formed according to the Plante process without any unusual expenditure of time or current and without the use of obnoxious additions to the electrolyte.

Storage Battery.—T. A. Edison, 871,214, Nov. 19, 1907. Application filed Oct. 31, 1900. Assigned to Edison Storage Battery Co.

This is one of the early applications of Mr. Edison for his storage battery and covers broadly some of its features. The first claim reads as follows: "In a reversible galvanic cell, an alkaline solution; an electrode consisting of an insoluble metallic perforated inclosing pocket, and a finely divided insoluble active material tightly packed in such inclosing pocket, and a second electrode." Metals suitable for the active masses of the electrodes are said to be cadmium for the positive element and copper oxide for the negative element.

Storage Battery.—H. E. R. Little, 870,973, Nov. 12, 1907. Application filed Jan. 17, 1907.

The cell is divided by a horizontal asbestos diaphragm into two compartments and carbon rods placed both in the lower compartment and in the upper compartment from the electrodes. The lower compartment is filled with carbon tetrachloride (or in general any liquid solvent of bromine, with a higher specific gravity than zinc bromide). The upper compartment is filled with zinc bromide. To charge the cell the carbons in the lower compartment are made the anodes and those in the upper compartment the cathodes. Zinc is deposited on the upper carbons while bromine is absorbed by the carbon tetrachloride. In discharging, bromine is withdrawn from the solution of carbon tetrachloride and zinc dissolves from the upper electrodes.

DISCHARGES THROUGH GASES.

Ozonizer.—Frank A. Ward, 871,652, Nov. 19, 1907. Application filed Aug. 23, 1906.

Air is purified by means of ozone produced in an ozonizer of the following construction: Within a cylindrical glass vessel a metallic rod is placed in the direction of the axle of the cylinder and a series of metallic discs are mounted on this rod at suitable intervals. Their peripheries or edges are notched to form points, which touch the inner surface of the glass cylinder. This forms one electrode. The other electrode is in form of a metallic cylinder which snugly fits the outer surface of the glass cylinder. This metallic cylinder is perforated.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Open-Hearth Process.—An interesting improvement in open-hearth steel production is described by Anson W. Allen (870,921, Nov. 12, 1907). Mr. Allen is the superintendent of the steel department of the A. & P. Roberts Co., Pencoyd, Pa. He finds that important improvements can be obtained by charging in a basic-lined open-hearth furnace a charge of iron and burnt lime, heating the same and then pouring upon the heated charge of lime and iron oxide a charge of molten metal. When this is done, a reaction immediately ensues in which the phosphorus and silicon of iron are caused to combine with the iron oxide and lime, forming a molten slag, so that the iron rapidly becomes dephosphorized and desiliconized. This reaction is not violent, and does not cause the overflow of the slag, and the slag containing the phosphorus and the silicon is allowed to remain floating on the surface of the metal. It is dense in its nature, and is not foamy and does not interfere with the transmission of heat to the iron below. The advantage of thus leaving the slag or the bulk of it remaining in the furnace is that a very large saving of iron is effected thereby. If the slag is immediately tapped off after a violent reaction, a large part of the iron oxide passes with it; but by allowing it to remain in the furnace the iron oxide contained in the slag reacts with the charge of molten iron decarbonizing it and giving up the iron of the slag to the bath. Scrap may be introduced into the furnace as part of the original charge, although an important advantage of the invention is that it is possible to conduct the open-hearth operation without the use of scrap. The following heat was made by the inventor: On the bottom of the furnace a charge of scrap steel was introduced, and upon it was placed iron oxide in the form of mill scale amounting to about 20 per cent of the metal charge of the furnace, and burnt lime amounting to about 4½ per cent thereof. Scrap was then placed on top of the lime and oxide, the total amount of scrap equaling about 20 per cent of the metal charge of the furnace. These materials were then heated for a period of one hour and a half until the iron oxide began to sweat or show signs of incipient fusion. Molten metal was then added to the furnace, it being introduced in two lots at an interval of 35 minutes apart. Each portion introduced amounted to 26,850 pounds and containing approximately 3.8 per cent of carbon and 0.8 per cent of phosphorus. At the introduction of the first lot of molten iron to the furnace a reaction took place which was quiet in its nature and not violent, and which produced a rapid elimination of the phosphorus from the metal, so that in 5 minutes the phosphorus was reduced to 0.612 per cent; in 10 minutes to 0.396 per cent; in 15 minutes to 0.288 per cent, and in 20 minutes to 0.070 per cent. On the introduction of the second ladle of iron, which was made 35 minutes after the pouring of the first ladle, a supplemental reaction ensued, and in five minutes thereafter the charge in the furnace contained .392 per cent phosphorus; in 10 minutes it contained .268 per cent phosphorus; in 15 minutes it contained .224 per cent; in 25 minutes .097 per cent phosphorus, and in 45 minutes .016 per cent phosphorus. The carbon was eliminated from the metal more slowly, and the entire heat lasted 4 hours and 55 minutes. The total metal output of this furnace was 72,390 pounds, or 6,520 pounds more than was charged into the furnace in the form of metallic iron, the addition being obtained from reduction of the iron ore. The slag was tapped from the furnace at the end of the heat, and was not removed previously. When tapped it contained 14.15 per cent of iron. The operation of the furnace was very rapid, and the inventor states that by following this process he is enabled to largely increase the output. For example, a furnace which previously yielded twenty 30-ton heats per week, by the new process will now yield twenty-six 30-ton heats per week. The advantages of the process are due to the fact that it enables one, without the use of the large scrap charge ordinarily employed in the pig and scrap process, which amounts approximately to 50 per cent or more of scrap, to produce basic open-hearth steel rapidly and with a minimum of labor and with a minimum of waste of iron, the essentials of the invention being the use of burnt lime as part of the initial heated charge of the furnace, and the retaining of the slag or the bulk of the slag in the furnace after the initial reaction takes place, in order that the iron of the slag may not be lost. If desired, mill cinder or iron may be substituted in whole or in part for the roll scale as the iron oxide to be employed in the reaction.

Sintering Flue Dust or Fine Ores.—James Scott, of Pittsburg, Pa. (865,658 and 865,659, Sept. 10), conglomerates finely divided ores or flue dust of blast furnaces, by dropping the fine dust in a shower through a furnace chamber, into which burners project in annular series at different levels, the heat being so regulated that the ore will be partially fused and concentrated during its drop through the chamber. The burners substantially provide annular sheets or flames at different levels through which the showering ore must drop. The bottom of the chamber is provided with a feed-out device, which aids in forming the partially fused material into lumps and discharges them into a water bosh, from which they are carried into a car by means of a conveyor which passes through this water bosh.

Copper.

Treatment of Low-Grade Copper Ores.—John A. Haralson, of Mexico, Mex. (867,360, Oct. 1) proposes to win copper from very low-grade ore in the following manner: A mixture of calcium sulphate and charcoal is heated in retorts to produce calcium sulphide and carbon dioxide. The latter gas is stored in a gasometer. A set of hydrogen-sulphide gas generators is filled with water, and in it the calcium sulphide is held suspended by bubbling the gas from the gasometer through the water upwards from the bottom. An ore mixer is filled with the crushed ore and a weak solution of sulphuric acid, whereby the copper is leached out. The gas which is developed is led to the gasometer mentioned above, while the mass of ore and copper sulphate solution is discharged into a filter which separates the solution from the solid matter. The solution is run into a receptacle, where the copper is precipitated by means of hydrogen sulphide. The copper sulphide is roasted and the sulphurous fumes are worked up into sulphurous acid.

Smelting Copper Ore and Converting Copper Matte.—Arthur M. Day, of Bingham Canyon, Utah (865,333, Sept. 3), patents a process in which the apparatus shown in vertical and horizontal section in Fig. 1 is used; *a* is a smelting vessel or converter with a nozzle *b* at the top and a wind-box *c* at the bottom. A number of tuyeres *f* extend upwards through the bottom, and for some cases they are provided with fusible tubular extensions *b* which extend from the bottom of the vessel to the top of the charge. The trunnion *d* is hollow, and is connected with the wind-box by a passage *g*, a compressed air supply pipe *h*, being detachable, connected with the trunnion. There are, further, several closed reservoirs *i*, each being provided at the top with a compressed air supply pipes *j*, while at the bottom connection is made with one or more auxiliary compressed air supply pipes *l*. Each of the pipes *l* is connected by a hose *n* with a pipe *o* leading to one of the tuyeres *f*. One of these reservoirs *i* is filled with powdered silica, a second

with powdered coal, coke or with oil, and still another with a flux, such as powdered limestone or iron ore. The vessel *a* is charged with the ore to be smelted; for instance, with crude copper sulphide ore, and is then tilted to receive molten matte through the nozzle *b* to start the smelting operation. This begins at the top of the charge, the air supply through the tuyeres being now turned on. The smelting progresses gradually downwards, and as the operation proceeds the smelting vessel is turned and the molten silica is drawn off from the surface through the nozzle. As the melting level progresses downward the tuyere extensions *p* are melted off and the air is delivered to the top of the ore next to the melted covering. When it is feasible the ore is mixed so as to produce a self-fluxing charge, but when this is not practicable the flux required to properly fuse the charge is supplied from one of the reservoirs *i* through one of the tuyeres. The oxidation of the sulphur and iron in the ore ordinarily produces sufficient heat to smelt the ore, but if this is not the case, powdered fuel is supplied from a second reservoir *i* through one of the tuyeres. To keep all the tuyeres open, a small quantity of powdered

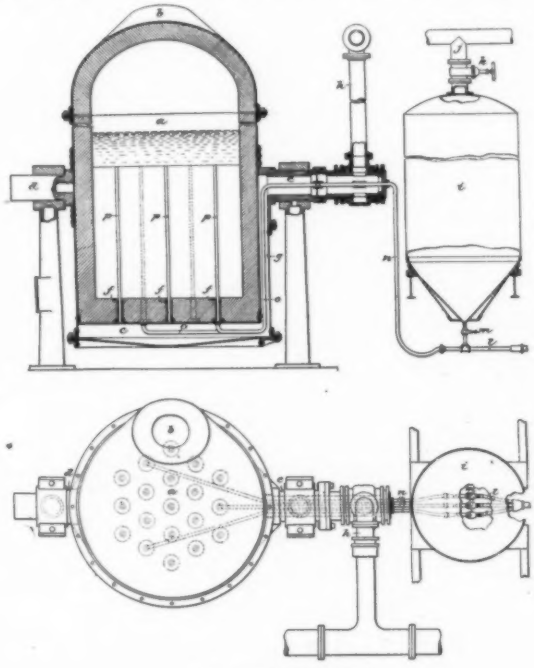


FIG. I.—CONVERTER.

silica, silicious ore or other silicious material in a fluent form is supplied from a third receptacle *i* to one or more of the tuyeres. The silica or other silicious material injected into the charge, while it is being agitated by the air blast, is diffused through the entire charge and brought into contact with the iron which is contained in the charge and with which it combines and forms a fluid slag. The chemical reaction which thus takes place throughout the entire molten portion of the charge, while the demand of the iron for silica is being satisfied, operates to keep the tuyeres open. In this way drifting or thrusting rods or bars through the tuyeres from time to time to keep them clear is avoided.

For the conversion of copper matte into pig copper the tuyere extensions *p* are not required, the air with the powdered silica being delivered directly from the tuyeres *f* into the lower part of the converter *a*. It will be seen that the chief feature of the process consists in the introduction of powdered silica through one or more of the tuyeres into the charge. The object is three-fold. First, to keep the tuyeres open without drifting; secondly, the silica combines with the iron contained in the matte and thereby liberates the copper; thirdly, this method admits of the use of ordinary fire-brick or clay linings in the smelting vessel of converter bowl, and thereby does away with destructible silicious linings.

Precipitation of Copper from Sulphate Solution.—Cement copper precipitated from copper sulphate by means of scrap iron requires purification. L. Jumau, of Paris, France (870,786, Nov. 12, 1907), claims to produce pure copper by heating the copper sulphate solution under pressure in the presence of a suitable sulphite such as ammonium sulphite or sulphurous acid. The copper is precipitated, while the sulphite is oxidized to sulphate or the sulphurous acid to sulphuric acid. The process is carried out in a digestor lined with lead, at a temperature of 170° C.

LEAD.

Lime Roasting.—A patent relating to this interesting subject has been granted to A. Savelsberg (870,690, Nov. 12, 1907). His argument is as follows: The desulphurization of sulphurous ores has been carried out in dividing the roasting process into a preliminary roasting in a revolving reverberatory furnace with the use of combustible material and into a final roasting in a converter. It would be advantageous to carry out both steps in the converter, but when this is fired the ore sinters during the preliminary roasting (which is not the case in the revolving reverberatory furnace, on account of the continuous stirring of the ore). This disadvantage must be overcome by mixing with the ore a material which can be easily made to swell and break up the sintered mass so as to make it suitable for the final roasting. Such a material is limestone, the swelling is produced by moistening. The process is, therefore, as follows: Limestone is mixed with the sulphurous ore and blowing in the converter begins. The ore is partially desulphurized and sintered together; the added limestone being contained in the mass partly in form of CaO and partly as $CaSO_4$, and partly, but least of all, as silicate. The superficially sintered mass has the shape of the converter, but still contains too much sulphur for the subsequent shaft-furnace process, and must therefore be desulphurized in a second blowing process. But for this purpose it must be pulverized, and this is simply done by pouring water over the sintered mass. The burned lime contained in it has an explosive effect when the water is soaked up so that the sintered mass is shattered, and can easily be brought into the state suitable for a second blowing process. In the case of ores which have the property of decomposing with subsequent damping with water in consequence of their own composition, no limestone is needed. The limestone, as well as the ore at the first blowing, may be employed in fairly coarse form. It would not be possible to roast to a finish by a single blowing in the converter in one operation, because the product which would become a hard sintered mass would contain too much unroasted sulphide ore and undecomposed sulphites enclosed within the roasted mass.

Sulphide Ores.—E. Dedolph, of Marysville, B. C. (870,668, Nov. 12) proposes the following treatment of sulphide ores of lead, copper, etc. The finely ground ore is intimately mixed with finely divided carbonaceous fuel, like sawdust, and is roasted in such a fashion as to oxidize the sulphur and a portion only of the fuel. The resulting product, consisting of the roasted ore and the unconsumed fuel, is then smelted. The following illustration is given. To a charge of 1,800 pounds of the ground ore about 50 pounds of sawdust are added. After the charge has been thoroughly mixed, it is roasted in an ordinary roasting furnace in the usual manner until all the sulphur fumes have been driven off. During this operation the volatile constituents of the sawdust, probably about 75 per cent thereof, are consumed, thus saving external fuel. The dense sulphur atmosphere formed in the roaster prevents the oxidation of the resulting fixed carbon or charcoal

and at the end of the roasting this remains intimately incorporated with the ore. During the smelting, which is carried on in a blast furnace in the ordinary manner, the 25 per cent of residual fuel, amounting to about 12½ pounds of finely divided charcoal, saves in the neighborhood of about 30 per cent of coke, or 54 pounds per charge, and this saving is practically clear gain, since the cost of the sawdust is negligible. It is stated that with this process it is possible to smelt ore running 70 per cent zinc.

Gold.

Slimes Filter.—D. J. Kelly and J. M. Callow, of Salt Lake City (865,912, Sept. 10, assigned to Kelly Filter Press Co., Salt Lake City), use a filtering apparatus consisting of a tank in which a carriage runs on tracks carrying the filters. Whenever the filters are heavily charged with separated solid material, and it is desired to remove the collected solid matter from the sides of the filter frames, the carriage is run out of the tank on to an exterior trackway. The special features of the present patent are details of construction of a locking-head connection between the pressure tank and the filter-frame carriage, by which a perfectly tight joint is formed around the open end of the tank to prevent any leakage at this point, and to securely lock the filter-frame carriage in its position in the tank.

Filter.—J. B. Stewart, of Peregina, Mex. (866,401, Sept. 17) patents a filter in form of a cylindrical drum with attached conical ends. The casing of the drum is perforated and carries a filtering cloth. Concentrically with this outer casing there

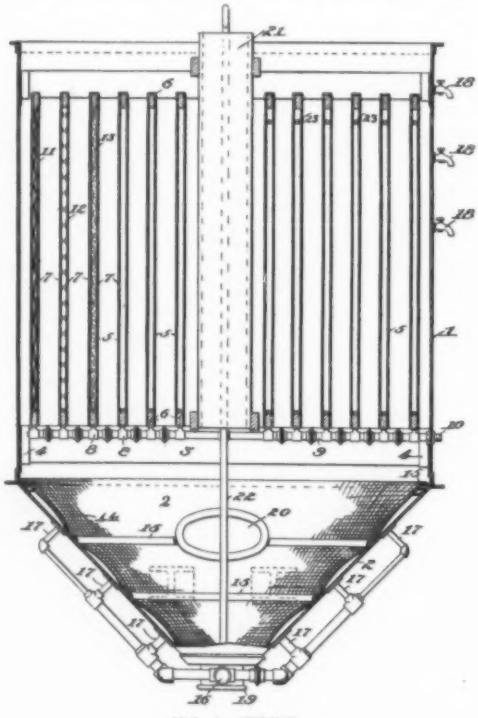


FIG. 2.—FILTER.

is provided an inner casing, so as to leave an annular space between the two casings through which the slime passes from one end to the other end. The inner casing is also perforated and is divided up into several compartments, which are connected by pipes to different solution tanks, so that the slimes are treated with different solutions while passing along through the annular space from one end of the drum to the other end.

Filter.—W. A. Hendryx (870,289, Nov. 5, 1907) patents the filter shown in Fig. 2. A charge of material is introduced into the tank through the box of pipe 21, while wash water, etc., is introduced through the pipe 16, passing by the several branch pipes 17 to the spaces beneath the canvas filter 14. The liquid thus introduced passes upward through the body of the ore pulp and is discharged through the filter cells 5. These filter cells are supported by transverse bars 3 and each cell comprises a wooden framework 6 with filter bags 7 of canvas. Each filter cell has a discharge 8 at the bottom connecting with the common main 9, which has an outlet 10. In order to prevent the collapse of the walls of the filter cells, they are filled with flexible cocoa matting, as shown in 11, or the walls are held in place by means of wooden strips 12, or the filter cells are filled with wooden blocks, as shown in 13. This filling of the filter cells does not prevent the passage of the liquid. The filter 14 serves as a very effective distributor for the inflowing liquor, while the cells 5 serve to distribute the outflowing liquor. In case the displaced liquid is substantially clear, the same or any portion of it may be decanted through the cocks 18.

Miscellaneous.

Melting Furnace.—Edward H. Schwartz (871,070, Nov. 12, 1907. assigned to Hawley Down Draft Furnace Co.) patents the furnace shown in Fig. 3. It is in form of a cylinder with conical ends. The end opening 8 is intended for pouring or

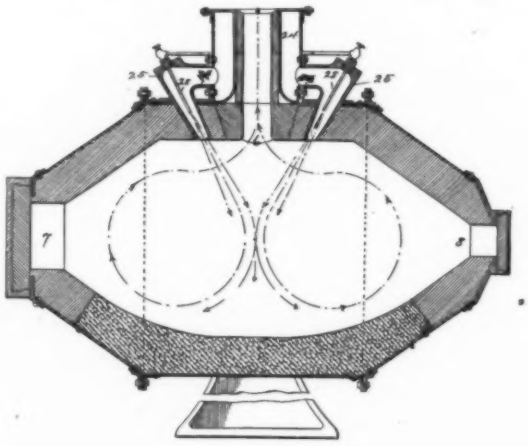


FIG. 3.—MELTING FURNACE.

tapping, and the opening 7 for charging. There are two burners 25, entering the top of the furnace on either side of the outlet opening 6, oil being supplied through the injectors 28. There are thus produced two flames which converge and meet at the central point of the furnace and form two rotary flames, as indicated by the dotted lines. During the melting operation the charge and the pouring openings are closed and the flames and products of combustion pass downward through the outlet 6 and the outlet extension 24, thereby heating the air in the latter chamber. Hot air is therefore introduced into the burners and a hotter and better flame is produced.

Furnace Doors.—In connection with the increasing use of electric power in steel mills, a patent of John C. Cromwell (869,960, Nov. 5, 1907, assigned to Garrett-Cromwell Engineering Co.) is interesting. It provides for electric operation of the furnace doors instead of the usual hydraulic operation. The front of the furnace has several ways in which the furnace doors may slide up and down, and each door is lifted through a chain connection by an individual electric motor, and is allowed to fall by its own weight. The several motors are hung on the frame of the furnace, so that they move therewith and occupy the same relative position to

the other parts in all positions of the furnace, which is a great advantage in case of a tilting furnace. The details of construction appear to be well worked out so as to make the arrangement fool-proof and the operation of the furnace doors as independent as possible of carelessness of the operator.

Reduction Without Smelting.—John D. Jones, of Iron Mountain, Mich. (866,280. Sept. 17, 1907), proposes to recover iron, manganese copper, etc., in form of pure metal from the ore, by putting the crushed ore, mixed with coke, into a stack of a height of about 100 feet. From a fire-box at the side of the stack at its bottom the products of combustion from soft coal are passed upwards through the mixture of ore and coke in the absence of air and without melting the ore. The combustion gases are mixed with the volatilized hydrocarbons from the soft coal.

Colloids.—In an editorial note in our November issue we discussed the various practical applications which the colloidal state now finds in the arts. A patent of Hans Kuzel, of Baden, Austria (871,599, Nov. 19, 1907), is interesting, since Kuzel has claimed to use colloidal tungsten for making the filament of his electric tungsten lamp. The method described in the patent is suitable for bringing highly refractory metals like tungsten, chromium, manganese, etc., into the colloidal state. For this purpose, the metal is first powdered as finely as possible, and is then subjected to treatment with various chemical reagents in alternating succession for more or less lengthy periods under moderate heating and energetic agitation. The best way is to first employ a solution of an acid character, and to follow this by a solution of a basic or neutral character, and then by a washing by diluted water or such organic liquids in which the solutions used are soluble, for instance alcohols, and so on. In the case of tungsten, the procedure is as follows: 10 kg. of tungsten are very carefully reduced to an exceedingly fine powder, and are then heated to a temperature of less than 100° C. for from 24 to 48 hours in a water bath with 75 kilograms of 15 per cent hydrochloric acid under thorough agitation and repeated renewal of the hydrochloric acid, and then separated from the acid by decantation and washed in the same way with distilled water until the hydrosol already formed begins to go into colloidal solution. The washing is interrupted and 75 kilograms of a 1 per cent solution of potassium cyanide are added to the substance and heating in the water bath under thorough agitation for about 5 to 24 hours again takes place, whereupon after washing with distilled water thorough agitation with a solution of acid character, for instance, 75 kilograms of a 1 per cent solution of ferrous sulphate for about 24 hours, takes place in a water bath. After this treatment and after complete removal of the iron by washing with distilled water, as a solution of basic character, for instance, a 2 per cent alcoholic solution of monomethylamin or a 0.5 per cent solution of caustic soda may be used, and so on. If the raw material was a sufficiently fine powder, a repetition two or four times of the treatment described above brings the tungsten into colloidal solution with distilled water. The colloidal tungsten may be readily and completely precipitated by the addition of a small quantity of an electrolyte, for instance, sodium chloride, and separated from the water by decantation.

Oxone and Regeneration of Air.

The Roessler & Hasslacher Chemical Co. have received a gold medal for their exhibit of oxone and other products of their works at the Jamestown Exposition, while Dr. Richard von Foregger has received a silver medal for the process of regeneration of air by oxone, which was in practical use in the Radium Booth of the Government. We will describe these interesting exhibits in full in our next issue.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals.

IRON AND STEEL.

Shrinkage Cavities in Steel Ingots.—Engineer A. Obholzer, in *Stahl und Eisen* for July 31 and Aug. 7, gives the results of using "Thermite" in the tops of heavy ingots to increase their solidity. Some fine photographs are given of ingots 2 and 4 tons weight, cast first without a sinking head and without after-pouring; next cast with a sink-head; next cast with a sink-head and with arrangements for keeping the sink-head hot while setting. All these showed progressive improvement, with successively larger proportions of the ingot sound and fit for use. Tests were then made with sink-heads, kept hot, and using in them so-called "sink-head thermite," contained in a box fastened tightly to an iron rod so as to be sunk 80 centimeters or deeper into the fluid steel. Immediately on introducing the thermit charge (consisting of iron oxide and aluminium powder) the reaction commences and is completed in 5 to 10 seconds, causing strong boiling up of the steel and bringing slag up to the surface plentifully. The slag is lifted off with a scraper, and more fluid steel poured in. The thermit box was 12 centimeters long by 10 centimeters diameter; cost, full of 1.3 kg. of mixture. $0.93, and sufficed for treating a 1-ton ingot. The Goldschmidt Thermit Co. puts up boxes marked 0, 1, 2, 3 and 4, holding, respectively, 1.3, 2.5, 5, 7.5 and 10 kilos of thermit mixture, and suitable for treating ingots of 0.5 to 1, 1 to 2. 5, 10 and 15 tons weight, respectively. By this treatment, ingots which are to be rolled or forged can be made entirely free from sink-head cavities. For best results, the sink-head should be one-fourth the height of the clean part of the ingot, and is partly filled with a lining of stamped-in poorly-conducting moulding sand, in order to reduce the radiation and keep the sink-head fluid. The opening on top need only be 20 to 30 centimeters across, so as to reduce radiation therefrom. Numerous analyses are further given of ingots cast without and others cast with thermit treatment, showing slightly less segregation in the latter case.

Determination of Chromium.—G. von Knorre, in *Stahl und Eisen* of Aug. 28, gives his most recent methods for determining chromium in steel, especially in presence of tungsten. In 1903, the author showed that persulphates convert chromic salts easily into chromic acid, and if the excess of persulphate is then destroyed by long boiling. the chromic acid can be determined according to known methods, such as by adding a measured quantity, in excess, of standardized ferrous sulphate solution acidulated with sulphuric acid, and determining the unused ferrous salt by permanganate:

$$6FeSO_4 + 2CrO_3 + 6H_2SO_4 = 3Fe_2S_3O_{12} + Cr_2S_3O_{12} + 6H_2O.$$

Ferric salts and copper salts do not interfere. Manganese can be simultaneously determined, as Ibbotson, Howden, Walters and Kleine have shown.

In steels not containing tungsten the chromium is determined without removing iron, as follows: The quantity taken is graded according to the chromium present; with small chromium content (less than 0.5 per cent), 6 to 10 grams; from 0.5 to 2 or 3 per cent, 1.5 to 6 grams; with high chromium steels or ferro-chrome, 1 gram or less. If it is not known approximately how much is present, use 3 to 6 grams. With less than 2 per cent of chromium present. 20 per cent sulphuric acid, cool at first and finally brought to boiling, brings all the chromium into solution, with 2 to 3 per cent chromium, longer boiling also takes up the chromium. A 14 per cent chromium alloy must be dissolved, however, in 50 per cent sulphuric acid. Nöther found this acid to dissolve completely, by long boiling, all the chromium in a 33 per cent alloy. After solution, the excess of free acid is neutralized by ammonia, caustic potash

or caustic soda, and then the solution of ammonium persulphate, 120 grams to the liter, is added in small portions until the ferrous salt present is entirely oxidized, as is determined by dropping in ammonia and seeing the brown ferric hydroxide; then an excess of 25 to 40 c.c. of persulphate solution is added. If it is desired to economize persulphate, the iron can be oxidized by nitric acid, which is added in small quantity to the original acid solution and heated to boiling; the free acid is then neutralized and some 40 c.c. of persulphate solution added. In either case, after the persulphate is added the solution is diluted to 400 or 500 c.c., 20 c.c. of dilute sulphuric acid, sp. gr. 1.16-1.18, added, and boiled 20 to 30 minutes. If manganese is present it separates out as hydrated manganese dioxide, which can be filtered out and the manganese determined in it; the chromium is now determined in the filtrate. Manganese only precipitates thus after the complete oxidation of the chromium to chromic acid. If no manganese is present it is advisable to boil only 10 minutes, cool, add more persulphate and boil again 20 minutes. The acidulated ferrous sulphate solution of known titrated strength is then added until the solution is green, the whole left 1 hour on the water bath, then the solution, strongly diluted, and the ferrous salt remaining titrated by permanganate solution, a fractional part of the main solution being used. Every three atoms of ferrous iron disappearing corresponds to one atom of chromium present as chromic oxide. The ratio is Cr = 0.3109 iron. It is of first importance that all persulphate shall have been removed by the half-hour boiling, else the titration will not be accurate.

In steels containing tungsten, the latter remains insoluble in sulphuric acid as a black powder. On oxidizing with nitric acid or persulphate some tungsten goes into solution, but most remains as hydrated tungstic oxide, which should be filtered out if in large quantity. To avoid this filtration, which goes slowly, there may be added sodium phosphate solution, which makes with the tungsten soluble sodium phospho-tungstate, which is not decomposed by mineral acids; enough concentrated caustic alkali solution is then added to make the solution strongly alkaline; sulphuric acid is then slowly added until the iron precipitate is entirely dissolved. Persulphate solution is then added, and the analysis finished as before, except that manganese is not simultaneously determined, because of the presence of phosphoric acid. High tungsten steels are not entirely dissolved by sulphuric acid, but are best boiled first with 50 per cent sulphuric acid until no trace of hydrogen is escaping, then nitric acid, sp. gr. 1.2, added in small quantities and the solution boiled a few minutes until the metallic tungsten is entirely oxidized to yellowish tungstic hydrate.

Tests on chromium steels, tungsten absent, showed results within 0.06 per cent in the extreme case of 14.60 per cent of chromium present; and a similar accuracy in steels with up to 5 per cent chromium and as much as 25 per cent tungsten.

Fuels.

Water Gas.—Director H. Dicke, of Frankfurt, gives in *Stahl und Eisen* for Aug. 14 and 21, a concise and useful review of the history of water gas and its present metallurgical uses. He recalls that in 1880 the Europaiska Wattergas Actie-Bolaget, of Stockholm, first introduced the American Lowe generator into Europe, and that next the sheet-iron works of Schulz-Knaudt, in Essen, put in a plant, using the gas for welding shafts. The latter plant was entirely rebuilt by E. Blass, in order to better adapt it to German conditions. In 1885, Mr. Blass reviewed the condition of the water gas industry (*Stahl und Eisen*, 1886, p. 3), showing that ordinarily 60 per cent of the fuel was used during "heating up," in making producer gas, and only 40 per cent was used when "cooling down," in making water gas; the water gas had about one-half of the calorific power of the fuel from which it was made. The Dellwik-Fleischer system changed all that; instead of blowing air 7 to 12 minutes for heating up and then steam for 6 minutes, cooling down, it was found practicable, with a very strong air blast, to run on air only 1 to 2 minutes, followed by steam 5 to 7 minutes. The very high velocity of the air blast prevented formation of producer gas, and burns the fuel which is oxidized entirely to CO^2, giving no producer gas as a by-product, and utilizing up to 75 per cent of the fuel for water gas instead of 40 per cent. This doubling of the efficiency of water gas production resulted in a rapid introduction of the system into many industries. For many years H. Dicke was the chief engineer of the Wassergas-Syndicats System Dellwik-Fleischer in Frankfurt.

Engineer Dicke then describes at length the construction and operation of the system, the details of which are unnecessary to repeat. In an hour the new producers are making water gas 50 minutes, while only 10 minutes altogether are used in heating up and changing connections. One man can attend a generator producing 1,000 cubic meters (35,000 cubic feet) of water gas per hour. The average analysis of practically made gas is given as

	Per Cent.
Hydrogen	49
Carbon monoxide	39
Carbon dioxide	5
Methane	0.7
Nitrogen	6.3

The rest of the first article is concerned with the detailed costs of welding iron and steel by use of coke, acetylene and water gas; showing that the cost of fuel is only half as much as using coke fire direct, and that the output is increased 80 per cent for the same labor costs.

In the second part, Dicke takes up the use of water gas in open-hearth furnaces, for gas engines and for lighting. In Siemen's furnaces it is unnecessary to preheat the gas, requiring, therefore, only a single-regenerator at each end of the furnace and a single pair of reversing valves. Even with this, higher temperatures and quicker melting can be obtained than with preheated producer gas. The attempt to use water gas mixed with producer gas in open-hearth furnaces was not satisfactory in Germany, and water gas is used alone. Nydquist and Holm, in Trollhätten, Sweden, erected early in 1906 two open-hearth furnaces of 5 and 8 tons capacity, run only on water gas, with most satisfactory results as to the quality of the steel. This so-called "water-gas steel" is sold as the finest quality of open-hearth steel, but costs no more than that made with ordinary producer gas. The same firm uses water gas in a regenerative crucible steel furnace, in which 10 crucibles are placed, each with 30 kilograms of charge, and melted down in 3½ hours, with a fuel consumption of 270 kilograms of fuel, including that used for raising steam for the producer. The temperature in the furnace is, by Seger cone, 1,840° C.

Small gas engines run very successfully on water gas. A 30-hp. engine of the Augsburg-Nurnberg make uses 0.86 cubic meters of gas per effective horsepower-hour. The gas having a calorific power of 2,450 Calories per cubic meter, this corresponds to 2,100 Calories furnished per effective horsepower-hour. This would correspond to only 2,800 Calories calorific power of the fuel used, or some 0.35 kilogram (0.75 pound) per effective horsepower-hour. With pure water gas, of above calorific power, it is not practicable to use it in engines over 50 hp., but gas of lower calorific power per cubic meter can easily be made by mixing the gas of the heating up period with the water gas, so as to make a gas with a calorific power as low as 1,100 Calories per cubic meter of the following composition:

	Per Cent.
Hydrogen	19
Carbon monoxide	21
Carbon dioxide	11
Methane	0.3
Nitrogen	48.7

One metric ton of coke will make 5,200 cubic meters of this gas, which will give one effective horsepower for each 0.4 kg. of coke used per hour, or adding in 0.1 kg. of coke for steam, 0.5 kg. (1.1 pounds) altogether. This gas can be used in gas engines of any size, and the calculation is made that in Germany (paying the head engineer, for instance, $1.10 per day, and his assistant $0.60) the total cost will be 3.64 pfennigs (0.9 cents) per effective horsepower-hour. By a recent patented process, Dr. Fleischer has succeeded in making a clean gas for power purposes from ordinary gas coal, avoiding altogether the presence of distilled tar in the gas. Altogether, fifty-four works are using at present eighty-seven water-gas plants on the Dellwik-Fleischer system for power purposes.

Illuminating gas is made much cheaper by this system than by any other; water gas is particularly suitable for use with the Welsbach mantle. One candle power will be given by an hourly consumption of 1.6 liters of water gas in a mantle, against 1.35 liters of distilled coal gas, but the former uses 4 Calories against the latter 4 Calories for the same amount of light. This difference is ascribable to the greater velocity of propogation of flame (ignition velocity) of water gas, giving a shorter but more intense flame. Many old gas plants use a supplementary water-gas plant, and mix water gas with their coal gas, thus utilizing their old plants and avoiding the benzol carburetting operation, by passing the water gas through the gas retorts during the distillation of the gas coal—the so-called "auto-carburetting" operation. The presence of the water gas in the retort during the early part of the distillation, in the first 2 hours, during which the high illuminants are escaping, largely prevents the splitting up of the latter and the deposition of retort carbon. It also facilitates the distillation process. The advantages of this auto-carburetting operation are so great that in a relatively short time the "Deutscher Wasser-gas-Beleuchtungs-Gesellschaft," in Berlin, has equipped twenty-four cities with this combination plant. The saving in benzol alone has reached $12,000 to $19,000 per year in the plant of a moderate sized city, paying for the cost of the Dellwik-Fleischer plant by this saving in less than eighteen months. This gas is so well suited for Welsbach burners that Dicke thinks it a matter of only a short time when the universal method of making illuminating gas will be: Distillation in retorts; use of part of the coke for firing the retorts; use of the rest of the coke in Dellwik-Fleischer water-gas plant; auto-carburization by passing the water gas through the distillation retorts. This mixed gas will have a calorific power of about 3,800 Calories per cubic meter, and cost only 0.37 cent per cubic meter (11 cents per 1,000 cubic feet).

TIN.

Detinning.—In *L'Industrie Electrique* of Oct. 25, a method of Theirot and Nougier is described for winning tin from tin scrap or from various tin residues. The process is said to have been in satisfactory commercial poeration for several years. The first step consists in the production of a solution of sodium stannate. This is then purified to remove especially copper and lead. Finally the pure sodium stannate solution is electrolyzed between iron anodes and tin cathodes. A solid adherent deposit of tin is obtained if the temperature is held as nearly as possible at 80° to 90° C., with a current density of 300 or 400 amps. per square meter (one side of the cathode only being counted). It is also necessary to maintain the solution sufficiently concentrated with sodium stannate and to submit it to strong circulation. Each bath absorbs 2.4 volts.

MISCELLANEOUS.

Synthesis of Precious Stones.—A paper presented by F. Bordas before the French Academy and printed in *Comptes Rendus* of Oct. 28, refers to the occurrence of corundum in nature in various colors. The different colors of the sapphires are generally attributed to the presence of impurities like chromium, cobalt, etc. Bordas, however, thinks that this is not true, since he could vary the color of the stones at will by submitting them to the action of radioactivity. When a bluish sapphire was subjected to the action of radium bromide, the color passed first into green, which then changed to a bright yellow and finally became dark yellow. When a red ruby was treated in the same way the color changed to violet, blue, green and yellow. The author proposes the hypothesis that precious stones of this kind found in nature occur in regions where the surrounding soil is radioactive, and that for this reason the yellow sapphires (being the final product) are the commonest.

Titanium in Steel Metallurgy.

Mr. CHARLES V. SLOCUM recently delivered a suggestive address on the applications of titanium before the Pittsburgh Foundrymen's Association. He mentioned some cases where unusual wearing qualities of car wheels were traced to the presence of titanium in the iron.

In 1895, Mr. Auguste J. Rossi smelted for the New York Car Wheel Works several hundred tons of ore high in titanium in a small blast furnace with a capacity of 3 to 4 tons per day. The iron obtained was a remarkably strong gray pig, and the object of the experiment was attained, namely, to show that titaniferous ores can be readily smelted in the ordinary way, if given proper attention and proper flux. Later on experiments were made by Mr. Rossi on the production of ferro-titanium in the electric furnace. These were described by Mr. Rossi himself in detail in our Vol. I., page 523.

The addition of ferro-titanium to steel materially increases the breaking strength. One reason why titanium is so effective in steel is that it eagerly combines with any nitrogen in the molten metal and thereby prevents the formation of blowholes.

Titanium is now also used as an addition in flame car lamp electrodes. Concerning Mr. Rossi, as the pioneer of titanium, himself, Mr. Slocum made the following remarks:

"Auguste J. Rossi is a Frenchman by birth. He was born in Paris in the last century, which, as he humorously expresses it, 'sounds well and is near enough.' He carried on his early studies at home and at the University of France, from which he graduated at the early age of 16 years and one month with the degrees of Bachelor of Science and Master of Arts. He then entered the Ecole Centrale of Arts and Manufactures and graduated three years later as civil and mining engineer at about 19½ years of age, having thus obtained four university degrees at an age when most young men are about entering college. Almost immediately afterward he came to this country, and was for twelve years technically in charge of the Boonton Iron Works of New Jersey. It was during this period that titanium seems to have attracted his attention, for during the past thirty years he has devoted much of his time and a great deal of labor and money to its study and the development of methods for its use, and has taken out many patents in relation to them. The most gratifying results have been obtained by the aid of the electric furnace. "Although a man well advanced in years, he is much pleased to have received from all parts of the world congratulations on the final success of a life of faithful, well-directed effort. It is not too much to believe that future generations will be proud to claim Auguste J. Rossi as one of America's adopted sons who has benefited the entire civilized world."

We have already noted that the ferrotitanium industry is now about to enter the commercial stage, and hope to publish more exact information on this interesting development in steel metallurgy in the near future.

Standardization.

The Institution of Mining and Metallurgy (London) has sent out an official announcement, stating that the following definitions have been adopted by the institution:

(1) The word "ton" shall represent a weight of 2,000 pounds avoirdupois (29,166.6 ounces troy). It is advisable to abandon the use of the terms hundredweights and quarters, and to express fractions of a ton in pounds or in decimals of a ton.

(2) The term "miners' inch" shall represent a flow of 1.5 cubic feet of water per minute; and the term "sluice head" shall represent a flow of 60 cubic feet of water per minute. It is advisable, however, to abandon the use of both terms, as being merely of local usage, in favor of definite expressions of the flow of water per minute, or per second, in cubic feet or in gallons.

(3) The word "gallon" shall represent the imperial gallon measure of 10 pounds of water.

(4) Temperatures shall be expressed in degrees centigrade.

(5) Returns of gold and silver shall be expressed in terms of fine gold and fine silver, respectively, not as "bullion."

(6) Gold contents of ores, etc., *determined by assay*, shall be expressed in money values as well as in weights; and in this connection the value shall be taken (as a convenient constant) at 85 shillings, or $20.67 United States currency, per troy ounce of fine gold.

Mesh of Wire Cloth.—The following table of "I. M. M. Standard Laboratory Screens" is intended for use in making grading tests and for the correlation of screens used in commercial or other work. When screens other than the I. M. M. standards are employed, the diameters of apertures should be given in any published results, so that comparisons may be made. When screens are described simply by the number of meshes per linear inch, it will be understood that the I. M. M. standard is referred to. The number of sizes standardized has been reduced to a minimum, as it is desirable to abandon excessive refinements in grading tests. It is believed that the I. M. M. standards will meet all necessary requirements of the laboratory. In reporting grading tests it is desirable to state whether wet or dry screening has been employed.

Table I. M. M. Standard Laboratory Screens.

Mesh or Apertures per Linear Inch.	*Diameter of Wire.*		*Aperture.*		*Screening Area.*
	Inch.	*MM.*	*Inch.*	*MM.*	*Per Cent.*
5	0.1	2.540	0.1	2.540	25.00
8	0.063	1.600	0.062	1.574	24.60
10	0.05	1.270	0.05	1.270	25.00
12	0.0417	1.059	0.0416	1.056	24.92
16	0.0313	0.795	0.0312	0.792	24.92
20	0.025	0.635	0.025	0.635	25.00
30	0.0167	0.424	0.0166	0.421	24.80
40	0.0125	0.317	0.0125	0.317	25.00
50	0.01	0.254	0.01	0.254	25.00
60	0.0083	0.211	0.0083	0.211	24.80
70	0.0071	0.180	0.0071	0.180	24.70
80	0.0063	0.160	0.0052	0.157	24.60
90	0.0055	0.139	0.0055	0.139	24.50
100	0.005	0.127	0.005	0.127	25.00
120	0.0041	0.104	0.0042	0.107	25.40
150	0.0033	0.084	0.0033	0.084	24.50
200	0.0025	0.063	0.0025	0.063	25.00

Whilst absolute accuracy to the fourth place of decimals of an inch is impracticable in the manufacture of wire cloth, a sufficiently close approximation to the above standards is attainable.

The adoption of a screening area of 25 per cent, necessitating equality of size of wire and aperture, secures perfect interlocking and consequent permanence of aperture.

Some of the finer mesh screens can only be woven in what is known as "twilled."

Ferro-Alloys in the Foundry.

An interesting paper on special ferro-alloys for the foundry was recently presented by Mr. E. Houghton, of Chesterfield, before the British Foundrymen's Association.

After having briefly sketched the development of the ferro-alloy industry, the author remarked that until recently its importance has been confined more or less completely to the steel works, including steel foundries, but now, quite a number of people are experimenting with ferro-alloys in ordinary iron founding, and, as the alloys become better known to foundrymen, it is not unreasonable to expect that they may play an important part in the foundry practice of the future. The object of their use in the foundry is of two kinds:

(1) To act as deoxidizers and desulphurizers, the added element remaining only in small quantities in the finished casting.

(2) To alter the composition of the casting and so to gain control of the condition of the carbon and the mechanical properties of the casting.

Ferro-Manganese and Spiegeleisen.—Compared with the old blast-furnace alloy, the characteristic features of the electric-furnace alloy are a much smaller amount of carbon, and, if desired, a higher percentage of manganese. Mr. Houghton remarks that from the foundryman's point of view it will always be best to use the rich alloys (or metallic manganese) rather than the lower grades, as by this means the alloy can be added solid to the ladle without unduly cooling it. If the very low grades are used it becomes necessary to melt them either separately prior to addition or along with the charge.

Mr. Houghton believes the latter plan is adopted in making chilled rolls in certain works where manganese is used to influence the chilling properties. But it is a question whether in this case the chill is all that can be desired, as a chill due to manganese is apt to show a sharp line of demarcation between the chilled part and the grey body of the casting, whereas a chill due to carbon alone should extend with roots into the casting.

Mr. Houghton's own conclusion in regard to the addition of alloys in general to cast iron is that much greater benefit will be secured by addition after melting, as will be mentioned below in connection with ferrosilicon.

In a paper which Mr. Houghton read at last year's convention, it was pointed out that use could be made of ferro-manganese in the removal of sulphur from common irons, and several instances were quoted in support of the statement. This, of course, can only occur where the pig iron is bad to start with, and must not be taken as an unqualified assertion that ferro-manganese added to any iron will improve it. It might do just the reverse in some cases. Excess of manganese hardens cast iron, the limit being about 1.25 to 1.75 per cent.

A considerable reduction in the sulphur content of iron melted in the air furnace could readily be brought about by addition of ferro-manganese to the molten metal in the furnace, and this without seriously increasing the manganese content of the final casting.

Moreover, at high temperatures manganese is readily oxidizable, and will rob iron of oxygen taken up as oxide in melting, although it is not so efficient in this respect as some of the alloys to be mentioned later. At the temperature of molten steel this property is very strong, but at the lower temperatures of molten cast iron it is less active. The presence of oxide of iron in cast iron is responsible in many cases for blame put on other things, and the good effects obtained by the use of special alloys are due, in many cases, solely to the removal of this oxygen from the metal.

Ferro-manganese is used by some carwheel makers, where it is thrown as a fine powder (about 1 pound to 300

pounds) into the bottom of the ladle before tapping. It is said that this permits of a much larger proportion of scrap being used along with poorer grades of pig iron, and that the depth of a chill can be regulated by varying the amount added.

It may, of course, be argued that where additions to pig-iron are necessary in iron foundry practice they may be obtained at less cost by the purchase of suitable pig iron rich in the desired element, and no doubt there is somethiing in this where there is sufficient chemical control to enable it to be carried out. Mr. Houghton is inclined to think, however, that many foundrymen would prefer to retain those mixings with which they have become familiar, and make any alterations they wish by means of an alloy rich in the desired element; the other constituents then remain unaltered, or nearly so. In any case, it would seem that additions made after melting the iron are most effective, and, after all, that is the point.

Silicon Spiegel.—The chief characteristic of blast-furnace silicon-spiegel is the high manganese and silicon (in the analysis given from 17 to 21 per cent Mn and from 9 to 15 Si), together with remarkably low total carbon (1 to 2 per cent), and it is interesting to note that when the silicon is under 10 per cent the carbon becomes more and more graphite. The electric-furnace products are, however, lower still in carbon.

Silicon-spiegel is used in steel foundry practice to prevent honey-combing, the silicon increasing the solubility of gases in the metal when solidifying, and the manganese removing oxygen from the iron and becoming oxidized itself.

A similar action should take place when the alloy is added to molten cast iron, particularly if melted in an air furnace, where higher temperatures can be attained than in the cupola.

The silicon should also have a softening effect on cast iron, which would be still further enhanced by the manganese accompanying it if the iron were previously too high in sulphur.

It seems as though there should be a use for this alloy in the iron foundry, as both manganese and silicon are deoxidizers of considerable power.

Ferro-silicon.—Ferro-silicon is now used very considerably in the foundry. Mr. Houghton refers to Mr. A. E. Outerbridge's well-known experiments. With ferro-silicon added in the ladle these experiments show gains "in transverse strength and deflection of as much as 24 per cent and 30 per cent respectively," and if this can be obtained regularly it is worth trying for. Mr. Outerbridge is, however, careful to point out that the silicon is much more effective when added in the ladle than when added in similar quantity to the mixture on the cupola stage, the chief benefit derived from its use being the deoxidization of the metal by removal of the oxygen taken up from the blast.

There is another very useful feature of silicon, and that is its well-known influence on the carbon contents, tending to convert it to the graphitic condition, and so produce a soft casting. For this purpose, there is no doubt silicon can, as a rule, be added to the charge without any additional expense by the use of glazed iron, but one needs to be careful that it is glazed foundry, not glazed forge iron; the latter is high in sulphur, and no good for softening purposes. This method, however, results in a more or less fixed product, and if the class of work requires considerable variation in the silicon content on the same day, it is at best a clumsy and indeterminate method.

On the other hand, by the addition of ferro-silicon, the silicon content of each ladle can be altered at will to suit the particular castings it is designed for.

Ferro-chrome.—If chromium is to be used at all in the foundry it will have to be used sparingly and for particular work only, mainly on account of its cost.

Since chromium converts carbon to the combined form, it is a hardener, whilst, generally speaking, in the foundry we are more concerned to find softeners. The writer has, however, lately heard of the use of chromium in the production of castings in which hard wearing properties are extremely desirable, and cost is somewhat secondary, as, for example, in cast-iron piston rings.

Ferro-Phosphorus.—Ferro-phosphorus is chiefly used to enrich the phosphorus in the slag from basic steel furnaces, so as to make it a saleable commodity.

The only possible use for such an alloy in the iron foundry would be in the production of very fine and thin castings, artistic work where excellency of detail was of permanent importance and strength secondary. From 2 to 5 per cent phosphorus, according to Prof. Turner, makes the metal very fluid when molten, and causes it to take an excellent impression of the mould.

Such castings are very brittle, but they have to be made sometimes, and, although phosphorus is an element one generally does not expect to have to pay for, but rather to claim something back for, still it may be there is a use for such an alloy in the foundry on work which is only very occasional.

Ferro-titanium.—Titanium combines eagerly with nitrogen as well as with oyxgen. To obtain perfectly sound castings it is important to remove all gases. Consequently an element which combines both with oxygen and nitrogen should be very beneficial in this respect.

It seems probable that combined nitrogen plays a very important part in reducing the strength of east iron, and if so it will be convenient to have an antidote so handy. Titanium is said to increase both the transverse strength and the hardness of the chill of cast iron.

Ferro-aluminium.—This is used almost solely as a deoxidizer, and it is very efficient in this role, but it is undesirable that much of it should remain in the metal. The chief drawback to the use of aluminium for this purpose is that solid alumina is produced which is apt to remain suspended in the metal, and this causes lack of continuity of the metallic structure and loss of strength sometimes.

There has consequently been a tendency to introduce mixed alloys. Of these, Mr. Houghton mentions ferro-aluminium-silicide, ferro-calcium-silicide, which is a very powerful deoxidizer, and ferro-manganese-aluminium-silicide, "which should be a very useful alloy for foundry purposes." The full paper which is printed in *The Iron and Coal Trades Review* (London) of Sept. 20, contains various analysis of commercial ferro-alloys, both blast-furnace alloys and electric-furnace alloys.

Aluminium Price Reduction.

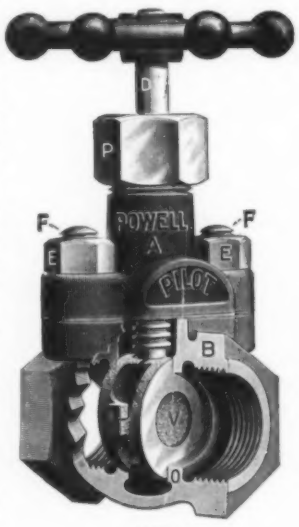
From Europe come reports of a considerable reduction of price in aluminium.

The London *Electrical Review* writes as follows: "For the moment the matter apparently mainly affects the continent of Europe, where conflicting reports are in circulation. On the one hand, it is stated that the price was reduced on Oct. 1 from 3s. to 2s. per kilogramme, or by 33 1/3 per cent, whilst on the other, it is declared that large contracts are still being booked at 2s. 9½d. per kilogramme. It appears, however, the real fact is that the principal producers have decided to lower the charge from 3s. to 2s., as from Jan. 1, 1908. No doubt the impending diminution, apart from the expanding output of aluminium, is prompted by the fall in the price of copper, as the former metal is becoming increasingly employed as a conductor as a substitute for copper in electrical work."

We may add that undoubtedly the erection of new aluminium plants in various European countries where the process is no longer protected by patents, has much to do with this reduction in price.

Valve.

The "Pilot" iron body gate valve is another addition to the already long list of steam specialties manufactured by the William Powell Company, of Cincinnati. The adjoining illustration shows a strong, compactly built valve with every detail carefully worked out. The iron body is built for service and is designed with heavy lugs on either side of the neck, carrying stud bolts F. The bonnet cap A has corresponding lugs drilled to template, which insures a perfect joint and constant alignment at all times, and also allows the bonnet to be replaced without unusual care after taking apart for inspection or repairs. Two semi-finished hexagon nuts E large enough to admit wrenching down hard, with a joint of the best packing material between the faces of bonnet and body, made an absolutely tight joint for all pressures up to 100 pounds. The large brass packing nut P should be noted affording plenty of room for packing material, to prevent leakage around the stem.



VALVE.

The brass stem D and bonnet are chased and cut to a true acme thread of unusual length, the best for wear. The length of thread keeps the stem in a true axial position at all times whether open or closed. The knobby hand-wheel gives a firm grip, even though the hands may be oily.

The discs are double, not a single wedge, with ball and socket back, making them adjustable. They are hung in recesses to the collar on the bottom of the stem. The discs, working in a tapering seat, expand or collapse in opening or closing, making a valve that will close down tight without straining or open easily, no matter what the conditions may be.

The Powell Pilot gate valve is also made all of iron, that is, discs, stem and packing nut are of iron; not a particle of brass used in its construction anywhere. This all-iron pilot gate valve will be found especially valuable in controlling ammonia, cyanide solutions, acids and all other liquids or gases that attack brass.

The Floating Battery of the Cambria Steel Co.

While the introduction of electric power for all purposes has revolutionized to a large extent the operation in modern iron and steel plants, the economies which may be obtained by the use of a storage battery are not yet fully appreciated. For this reason the following notes, taken from a recent pamphlet of the General Storage Battery Co., of New York, should be interesting.

There are many plants in which a large part of the electric power load is at a considerable distance from the generating station, where the installation of a suitable storage battery, floating on the line, at or near the local center of distribution of the distant load, will produce excellent results. By increasing the load factor (that is the figure which indicates to what extent the maximum capacity of the plant is utilized in average operation) it will effect a great saving in plant operation. It will also maintain an increased and steady voltage at the load, and increase the plant output at far less cost than would be necessary for an increase in the generating equipment.

The Cambria Steel Co. uses two large ore bridges and one car dumper, all operated by electric motors and supplied with current by a set of feeders from the main power house, the center of the load being approximately 3,000 feet from the power house.

The work of these motors is of necessity heavy and intermittent, so that the resultant load on the power house fluctuates widely. The momentary current values vary from 400 to 4,000 amps., equivalent to rapid fluctuations in load from 100 to 1,000 kw. at 250 volts.

Prior to the installation of the storage battery, twelve 500,000 C.M. cables were used as feeders (six outgoing and six returning), to supply the motors operating the ore bridges and car dumper. The voltage at the center of the motor load, at the same time, fluctuated through wide limits.

To meet the demands for an increase in load, it was found necessary either to increase the generating plant, or relieve it of power fluctuations to such an extent that additional load could be handled by the existing units.

It was found, as is usually the case, that the installation of a storage battery near the center of load could be made at much less cost than an increase in generating equipment, and would have the additional advantage of increasing the load factor of the plant, with consequent more economical operation. Besides this the voltage at the center of load could be maintained at a higher working value, and the battery could be used in emergencies as a reserve.

Calculation showed, also, that the feeder copper which could actually be removed, following the installation of a battery at the center of the load, would go a long way toward paying for the battery.

To attain these advantages it was necessary, however, that the storage battery installed should go from charge to discharge, with small changes in voltage at its terminals; should be capable of being operated with little or no attention; should be able to withstand occasional overloads without detriment; and, in emergency, be able to stand fully discharged for short periods, without permanent injury.

As the construction of the Bijur "High-Duty" batteries (an illustrated description of which may be found on page 203 of our Vol. III.) lends itself admirably to these requirements, it was decided to install a battery of this type. It consists of 106 cells of the General Storage Battery Co.'s regular Bijur "High-Duty" type, having a capacity of 2,400 amps. for 20 minutes.

Each cell has twenty-five plates, approximately 15½ x 15½. The plates are burned to bus-bars of rolled lead, except in the terminal cells, where the bus-bars are provided with internal copper conducting reinforcements. The connections between adjacent rows of cells are made by means of lead-covered copper bar.

The lead-lined containing tanks are sufficient in size for thirty-one plate elements, providing for future increase in the capacity of the battery.

Each tank is provided with double insulation, the glass insulators supporting the wood stringers resting on vitrified tiles set in the concrete floor of the battery room.

The battery house is of brick, with slate roof and concrete floors; the building is well lighted and is provided with drains, so that the entire battery room may be flushed out. A separate room is provided in the building for the battery switchboard.

The switchboard in the battery sub-station is provided with a distant control circuit breaker which may be opened or closed by hand at the battery house, or electrically from the power station. The arrangement is such that opening of the circuit breaker is immediately signaled in the power station, and this breaker can be closed from the power station by the switchboard attendant.

Owing to the distance (3,000 feet) between the battery and

power station, it was found that comparatively small changes in current over the feeders to the battery would produce sufficient change of voltage at its terminals (due to feeder drop) to cause it to go from full charge to full discharge; in fact, the battery so situated removes the fluctuations from the power station to such an extent that it was not considered worth while to install a regulating booster at the power station.

By the selection of the proper number of cells, the battery has been arranged so that while merely floating on the line, its total charge and total discharge over an extended period are equal, hence the state of charge of the battery remains substantially constant.

In order, however, to provide for an increase in the condition of charge, and to give occasional overcharges, required for best operation, a separately excited motor-driven booster is installed in the power station. Provision is made for connecting the booster armature in series with the battery feeders, between them and the station bus-bars, the voltage then being raised by hand regulation to the extent desired to overcharge the battery. This overcharging with the hand regulated booster is usually done at times when the ore bridges and car dumper are not in operation, although it may be done at any time.

The construction of the battery plates in this installation is one offering the greatest freedom to diffusion of the electrolyte. The cells can be charged completely full with less than 2½ volts each, at the normal 8-hour rate. This feature ensures charge and discharge taking place with minimum changes from an average floating voltage; a feature affording high working efficiency.

The plates are also free from mechanical disturbances of any kind, so that in practice the battery house is left entirely without attendance for a week or more at a time, the only attention required being the occasional replenishing of the cells with water to provide for evaporation and general inspection of the battery. Emergencies in which the battery has been compelled to remain without attention for protracted periods, and in which its reserve function has been called upon to its fullest extent have been met, without any detrimental effect whatsoever.

Summarized, the results which have been attained by the Cambria Steel Co. from this installation are as follows:

(1) Saving in initial cost over generating equipment of equivalent capacity.

(2) Saving of 27,700 pounds of copper removed from the feeders.

(3) Removal of fluctuations from the power station.

(4) Increase in the working voltage.

(5) Reduction of feeder losses.

(6) Increase of station output from existing units.

(7) Creation of a reserve source of supply.

Notes.

American Electrochemical Society.—At the meeting of the board of directors, held at New York City, Oct. 17, the following gentlemen were elected members of the American Electrochemical Society: Delos G. Giles, manager, Elmira Machine Works, Elmira, N. Y.; Louis I. Waldman, president, Hudson River Aniline Color Works, Albany, N. Y.; Louis V. Emanuel, American Smelting & Refining Co., Maurer, N. J.; John Gaub, New Jersey Agricultural Experiment Station, New Brunswick, N. J.; Noel Statham, West Virginia Pulp & Paper Co., New York City; Federico Giolitti, Ph. D., professor of metallurgy, University of Rome, Rome, Italy; Richard H. Gaines, chemist, New York Board of Water Supply, New York City; Edwin F. Northrup, The Leeds & Northrup Co., Wayne Junction, Philadelphia, Pa. At the meeting of the board, held in Philadelphia on Nov. 26, the following gentlemen were elected members: Howard D. Smith, Ph. D., Beloit College, Beloit, Wis.; William H. Bassett, chemist, the American Brass Co., Waterbury, Conn.; H. Clyde Snook, A. M., president, Roentgen Manufacturing Co., Philadelphia, Pa.; John Clement Bradley, assistant chemist, the American Brass Co., Waterbury, Conn.; F. Fichter, Ph. D., professor of organic chemistry, University of Basel, Basel, Switzerland; William C. Geer, chief chemist, the B. F. Goodrich Co., Akron, Ohio; Dr. Georg Langbein, Hofrath, manager, Langbein Pfanhauser-Werke-A. G., Leipzig, Germany; Axel O. Appelberg, Ph. D., research chemist, General Electric Co., Schenectady, N. Y.; Colin G. Fink, Ph. D., research chemist, General Electric Co., Schenectady, N. Y.; Charles F. McKenna, Ph. D., chemical engineer, New York City.

American Foundrymen's Association.—At a meeting of the executive board it was decided to hold the next convention at Toronto, Ont., the time to be the first week in June as usual.

Niagara Falls of To-day.—The Board of Trade of Niagara Falls, N. Y., has recently issued an illustrated pamphlet, with numerous illustrations, giving outside views of many of the principal industrial plants located there. A map of Niagara Falls shows in red the lands controlled by the different power companies for the location of industries.

Oil Refinery.—The October issue of *The Outlook* contains a well-written article of a popular nature on the industrial system of the Standard Oil Company, by Harold J. Howland.

Tungsten.—The Atolia Mining Co., of San Francisco, operating the Randsburg (California) Tungsten mines, which have in the past been one of the largest American producers of Tungsten ores, have closed down their mines indefinitely.

Alundum as Abrasive.—The Norton Co., of Worcester, Mass., have recently issued an interesting and nicely illustrated pamphlet on alundum, its invention and use. Alundum is purified bauxite. The bauxite from the Norton Co.'s own mines is heated in calciners to drive off the combined water, and is then melted in electric furnaces at a temperature of 5,000° to 6,000° F. The electric-furnace plant is located at Niagara Falls. The electric furnace treatment insures the purity and uniformity of the alundum. The alundum is worked up into ginding wheels, rubbing and sharpening stones in the Worcester plant. The chief claims made for alundum as an abrasive are great sharpness, great hardness, right "temper" (*i. e.*, strength of grain and character of its fracture under grinding pressure) and absolute uniformity.

Internal Combustion Engines.—The November issue of *Cassier's Magazine* is entirely devoted to internal combustion engines. After an historic review of the subject by H. H. Suplee, the practice of construction of large gas engines in America, England and Germany is discussed by E. T. Adams, W. H. Booth and F. E. Junge, respectively. There are also articles on the utilization of blast furnace gases, by B. H. Thwaite and Leon Greiner; on the use of low-grade fuels in the gas producer, by C. T. Wilkinson; on gas-power applications, by J. R. Bibbons; on the by-product gas producers, by H. A. Humphrey; on the use of bituminous coal in the gas producer, by E. A. Harvey; on the suction gas producer, by F. J. Rowan and J. M. Tart, and other articles and notes.

Production of Gold and Silver.—Figures have just been published by the Bureau of the Mint and the United States Geological Survey on the production of gold and silver in the United States in 1906. The total production of gold was 4,565,333 fine ounces, valued at $94,373,800, an increase of 299,591 ounces over 1905. The largest increase was in Alaska (increase, 311,511 ounces) and Nevada (189,606 ounces), while Colorado shows a decrease of 133,839 ounces. Nevertheless, Colorado still heads the list of gold-producing States and Territories, with a yearly production of 1,109,452 ounces, while Alaska is now a very close second, with 1,033,537 ounces. California is third, with 911,041 ounces. The total production of silver in 1906 was 56,517,900 fine ounces, valued at $38,256,400, an increase of 416,300 ounces over 1905. The largest in-

crease was in Utah (increase 1,188,200 ounces) and Idaho (710,600 ounces), while Montana shows a loss of 914,400 ounces, Nevada of 655,900 ounces, and Colorado of 495,400 ounces. The chief silver producer is still Montana, with a yearly production of 12,540,300 ounces. Colorado is second, with 12,447,400 ounces. Utah is third, with 11,508,000 ounces. The complete figures may be found in an advance chapter from *Mineral Resources*, by Waldemar Lindgren, on the production of gold and silver in 1906.

Sand-Lime Brick.—The manufacture of sand-lime brick is rapidly becoming an important industry in the United States and is likely to be as profitable here as it has been in Germany for the last ten years. A sand-lime brick is essentially a mass of sand cemented by hydrous lime silicates. The bricks can easily be made with a crushing strength of over 4,000 pounds per square inch, exceeding in this respect some sand-stones, and a tensile strength of over 200 pounds per square inch, and they withstand severe freezing, thawing and fire tests. When made with pure sand their color is white, but by the addition of manganese or graphite in varying proportions, gray or pink brick may be produced. Both common and front bricks are made. Their chief merits seem to be their white color and their somewhat lower cost of manufacture than that of clay or shale bricks used for building fronts and for ornamental purposes. It is claimed that they make rigid structures and that they are in every way safe and satisfactory as building material. A brick plant for making sand lime bricks, near Sayreton, a village just north of Birmingham, Ala., is briefly described in a paper by Charles Butts in the annual economic bulletin (No. 315) of the United States Geological Survey for the year 1906. The paper includes a list of publications dealing with the subject of sand-lime bricks.

Norwegian Water-Power and Foreign Capital.—The King of Norway has given his consent to the bill passed by the Storthing in relation to the utilization of water-power. It is provided under the new act that embankment and deepening of works for the regulation of a water course, even if the cession of soil and land that are not one's own is not required for the execution of the works, cannot be taken in hand without previously obtaining the consent of the King, as soon as the water-power used by the undertaking for industrial purposes is increased to at least 3,000 hp. During the proceedings in the Storthing, in respect of the regulation of the Miosen Lake—the largest in Norway—the Opposition to the Government did not conceal that in contesting the Government's decision they were materially concerned with rendering it as difficult as possible for foreign capital to "exploit" the rich water powers of the Glommen for industrial establishments. The Opposition even went so far as to accuse the Government of injuring the interests of the country for the advantage of foreign capitalists. Immediately on the day following the victory of the Government in the matter of the Miosen Lake scheme, the Opposition brought in a motion, which has now become law, by the giving of the King's assent, as already mentioned. This motion was adopted by the Storthing without noteworthy discussion, although it was opposed by the Government on the ground that the proposal represented a rupture of all traditional customs and an interference with private rights in property. But the Government itself had already embarked upon this path by having established the completely new principle for Norway that the natural riches of the country represent, in a certain measure, State property, and that the State has the right of utilizing these riches for its advantage. It is recalled in this connection the fact that in the spring of this year a wealthy German company, which wished to acquire the whole occurrence of ore near Salangen, in Finmark, was compelled to pay 36,000 kronen ($9,000) to the State for the grant of the concession. In addition to this, a Swiss company obtained permission to utilize the water-power of the Kinserbach only on the express condition that the whole installation should revert to the State free of charge at the expiration of seventy-five years. The correspondent adds, that foreign capital scarcely runs the danger under the present ministry of being burdened "any more than necessary," but he predicts a bad time for foreign capitalists when the present Opposition should become the government of the day, and they are now preparing a plan of campaign with the object of securing the political control of the country.—(*London Electrical Review*, Oct. 4.)

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbide (*Continued.*)

No. 601,367, March 29, 1898, C. L. Wilson, C. Muma, J. W. Unger, H. Schneckloth, A. P. Brosius and J. C. Kuchel.

Sticks of compressed lime and carbon are fed downward through (seven) holes in a vertical carbon electrode into an arc sprung to a disc electrode beneath. At the top of the upper electrode is a cylindrical insulating extension, also having holes for the sticks. When the current is weak, sticks may be fed through some but not all of the holes in the upper electrode. The smelting zone is inclosed by a two-part metal hood, which is movably supported by cables. The brick base and the metal sides of the hood are protected with a mass of pulverized carbide. As reduction proceeds the molten product accumulates on the pulverized carbide lining, and the upper electrode is gradually raised. At the finish the hood is raised and the mass of carbide on the brick base allowed to cool.

No. 609,864, Aug. 30, 1898, Matthew P. Wood.

Economizes electric current by preheating cylindrical blocks of a mixture of pulverized graphite or other form of carbon, lime and 1 to 3 per cent of a binder, *e. g.*, coal-tar, pitch, resin, asphaltum, molasses or sugar. A series of these blocks are fed vertically downward through holes in the roof and hearth of a Siemens regenerator furnace. The blocks are heated in this furnace by the combustion of gas to, say, 4,000° F., and an electric current is then passed through them, from carbon anodes lowered through the holes in the roof into contact with the upper ends of the hot blocks, thereby raising their temperature to from 5,000° F. to 6,300° F. The blocks are thus converted into molten calcium carbide, which is tapped out of the furnace hearth. Hydrocarbons may be supplied to the furnace chamber, to give an oxidizing or non-oxidizing flame, as desired. The fusion of the charge-blocks is said to begin at their tops, where they contact with the anodes, streams of molten carbide coursing down the blocks.

No. 629,394, July 25, 1899, Isaiah L. Roberts, N. Y. City.

Feeds charge through a square carbon chute onto a horizontal resistance grating of bars spaced apart one-eighth or one-quarter of an inch and removably supported in notches in the opposed ends of massive conductors. The spaces between the bars are initially filled by small pieces of carbon or coal. The produced carbid melts and drops through the spaces into a chamber below, closed by a transversely sliding gate. When the gate is opened the carbid falls into a vessel removably secured below. A pipe leads the carbonic-oxid gas from below the zone of reduction into the space above the receiving vessel, to displace air. The walls of the furnace consist of fire brick lined with compressed magnesia and surrounded by slaked lime or calcium magnesia and a sheet-iron casing. The leading-in conductors are surrounded with asbestos. Good contact with the resistance bars is effected by a paste of graphite and water. A carbon resistance-pan may be substituted for the bars. The furnace may be used for the reduction of sodium potassium or zinc, an iron resistance-pan being suitable. These metals volatilize and condense in the chamber below.

(*To be continued.*)

NEW BOOKS.

THE CHEMISTRY OF COMMERCE.—A simple interpretation of some new chemistry in its relation to modern industry. By Robert Kennedy Duncan. 262 pages, 58 illustrations. Bound in cloth. Price, $2.00 net. New York: Harper & Brothers.

PAPERS AND ADDRESSES OF THE NINTH ANNUAL SESSION OF THE AMERICAN MINING CONGRESS, 1906.—Containing portraits of the officers and directors of the American Mining Congress. 151 pages; paper cover. Denver, Col.: Office of the Secretary.

ZINC AND LEAD ANNUAL.—Webb City, Carterville mining district. Edited by Jesse A. Zook and W. S. Baxter. 48 pages. Paper binding. Price, 10 cents. Joplin, Mo.: Zook & Baxter.

TRAITE DE CHIMIE ANALYTIQUE QUALITATIVE SUIVI DE TABLES SYSTEMATIQUES POUR L'ANALYSE MINERALE.—By Louis Duparc and Alfred Monnier. 374 pages; illustrated. Paper binding. Price, francs 6. (Retail price in New York, $1.50.) Geneve: Librairie Kündig.

CHEMICAL REAGENTS, THEIR PURITY AND TESTS.—A new and improved text based on and replacing the latest edition of Krauch's *Die Prüfung der chemischen Reagentien aus Reinheit.* By E. Merck. Authorized translation by Henry Schenck. 250 pages. Bound in cloth. Price, $1.50 net. New York: D. Van Nostrand Co.

PRACTICAL TEXT-BOOK OF CHEMISTRY.—By John Dabney Palmer. 190 pages. Bound in cloth. Price, $1.00 net. New York: John Wiley & Sons.

THE MICROSCOPY OF TECHNICAL PRODUCTS.—By Dr. T. F. Hanausek. Revised by the author and translated by Andrew L. Winton with collaboration of Kate G. Barber, Ph. D. 471 pages; 276 illustrations. Bound in cloth. Price, $5.00 net. New York: John Wiley & Sons.

THE PHYSIOLOGY OF ALIMENTATION.—By Dr. Martin H. Fischer. 348 pages; 30 illustrations. Bound in cloth. Price, $2.00 net. New York: John Wiley & Sons.

CLEAN WATER AND HOW TO GET IT.—By Allen Hazen. 178 pages. 14 full-page half-tone illustrations. Bound in cloth. Price, $1.50 net. New York: John Wiley & Sons.

THE INTERPRETATION OF GAS ANALYSIS.—By Woodbridge Hale Birchmore, Ph. D. Explicit directions for making deductions needed for utilizing information given by a chemist's report of an analysis of illuminating gas, in respect to the problems daily demanding solution in business life. 75 pages. Bound in cloth. Price, $1.25 net. New York: D. Van Nostrand Co.

SOLUBILITIES OF INORGANIC AND ORGANIC SUBSTANCES.—Compiled by Atherton Seidell, Ph. D. A hand-book of the most reliable quantitative solubility determinations. 380 pages. Price, $3.00 net. New York: D. Van Nostrand Co.

THE ELEMENTS OF PHYSICAL CHEMISTRY.—By Harry Clay Jones. Third edition revised and enlarged. 659 pages; illustrated. Price, $4.00. New York: Macmillan Co.

FIRST PRINCIPLES OF CHEMISTRY.—By Raymond B. Brownless, Robert W. Fuller and others. 425 pages; illustrated by tables and diagrams. Bound in cloth. Price, $1.25. Boston, Mass.: Bobst, Allyn & Bacon.

THE CHEMISTRY OF PAINTS AND PAINT VEHICLES.—By Clare H. Hall. 134 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: D. Van Nostrand Co.

AMERICAN SOAPS, CANDLES AND GLYCERIN.—A practical manual of modern methods of utilization of fats and oils in the manufacture of soap and candles and of the recovery of glycerin. By Leebert Lloyd Lamborn. 706 pages; illustrated. Bound in cloth. Price, $7.50 net. New York City: D. Van Nostrand Co.

GLUE AND GELATINE.—A practical treatise on the methods of testing and use. By R. Livingston Fernbach. 208 pages; illustrated. Bound in cloth. Price, $3.00 net. New York: D. Van Nostrand Co.

HARPER'S ELECTRICITY BOOK FOR BOYS.—By Jos. H. Adams. With an explanation of electric light, heat, power and traction, by Jos. B. Baker, technical editor *United States Geological Survey.* 407 pages, numerous illustrations. Bound in cloth. Price, $1.75. New York: Harper & Brothers.

A TEXT-BOOK OF ELECTRICAL ENGINEERING.—By Dr. Adolf Thomälen. Translated from the German by G. W. O. Howe. 464 pages; illustrated by diagrams. Bound in cloth. Price, $4.20 net. New York: Longmans, Green & Co.

GAS AND OIL ENGINES AND GAS PRODUCERS.—A treatise on the modern development of the internal combustion motor and efficient methods of fuel economy and power production. By Lionel S. Marks and S. S. Wyer. 142 pages; illustrated. Bound in cloth. Price, $1.00. Chicago, Ill.: American School of Correspondence.

STEAM BOILERS, THEIR THEORY AND DESIGN.—Third edition. By Harry de Berkeley. 394 pages; illustrated. Bound in cloth. Price, $4.00 net. New York: Longmans, Green & Co.

Advance chapters from Mineral Resources of the United States for 1906, Washington, D. C., United States Geological Survey:

THE PRODUCTION OF MANGANESE ORES IN 1906.—By Edwin C. Ecker. 11 pages.

THE PRODUCTION OF ANTIMONY, ARSENIC, BISMUTH AND SELENIUM IN 1906.—By Frank L. Hess. 16 pages.

THE PRODUCTION OF GRAPHITE IN 1906.—By George Otis Smith. 7 pages.

THE PRODUCTION OF NICKEL, COBALT, TUNGSTEN, VANADIUM, MOLYDENUM, TITANIUM, URANIUM AND TANTALUM IN 1906.—By Frank L. Hess. 26 pages.

THE PRODUCTION OF COAL IN 1906.—By Edward W. Parker. 195 pages.

STATISTICS OF THE CLAY-WORKING INDUSTRIES IN THE UNITED STATES IN 1906.—By Jefferson Middleton. 55 pages.

THE MANUFACTURE OF COKE IN 1906.—By Edward W. Parker. 59 pages.

BOOK REVIEWS.

KURZES LEHRBUCH DER ORGANISCHEN CHEMIE.—By William A. Noyes, professor of chemistry at the University of Illinois. Authorized German translation by Walter Ostwald. With a preface by Prof. Wilhelm Ostwald. 722 pages; illustrated. Leipzig: Akademische Verlagsgesellschaft m. b. H.

It is a significant fact that the work of American chemists attracts a steadily increasing interest in Germany.

The text-book on organic chemistry by Prof. William A. Noyes, which here appears in German translation, is so well known to American chemists that it is unnecessary to explain its scope and character. But it will certainly be of interest to quote the preface by Prof. Wilhelm Ostwald in free translation:

"This addition of another book—the translation of an American text-book—to the exceedingly long list of German treatises on organic chemistry is justified by the great independence and originality shown by the author in conceiving and solving his task. In view of the immense accumulation of isolated facts relating to organic chemistry, it is of decisive importance for the beginner to gain command as early and as thoroughly as possible of the outlines of the system which connects these facts. By an original arrangement of the material, the author has indeed succeeded in attaining such a symmetry and such a clear view over the whole subject that the student, after having mastered this little book, may continue his studies in full confidence that he can no longer get lost in the forest of organic chemistry. It is especially noteworthy that the author has succeeded in solving the difficult problem of bringing clearly before the student the vast fields to be mastered later on without discouraging him. The foundation of the author's success is his great clearness of explanation, which makes the student feel at home in the field cov-

ered in the book, and thus gives him the confidence of also mastering the rest. I may add that the modern achievements of general chemistry have found full consideration; this explains the writer's personal interest in this work." This preface is signed by Ostwald from his cottage "Energy" in Gross-Bothen. The translation into German appears to be excellent—the translator being evidently Prof. Ostwald's son. Prof. Noyes has himself made some additions to the text. There is a very full index of 36 pages.

* * * * *

ANNUAIRE UNIVERSEL DES MINES ET DE LA METALLURGIE. By Robert Pitaval. 348 pages, with several maps. Paris: Société des Publications Scientifiques et Industrielles.

This new French yearbook is essentially a collection of addresses of mining and metallurgical companies, arranged according to countries and each country being sub-divided according to products, coal, iron, etc. Occasionally a very short indication is given of the equipment of the works, but such indications are too few and too brief to be of value. However, when nothing is desired but a list of names of companies producing a certain product in a certain country, this annual would be useful.

The following countries are covered in the book: France, Algeria, Tunis, Madagascar, New Caledonia, Tonkin, Belgium, England, Germany, Luxemburg, Austria, Hungary, Holland, Italy, Servia, Bulgaria, Bosnia, Herzegovina, Greece, Turkey, Sweden, Norway, Denmark, Russia, Spain, Portugal, United States, Mexico, Chili, Peru, Bolivia, Brazil, Argentine, Venezuela, Costa Rica, Cuba, Ecuador, Japan, Canada, South Africa, Transvaal, India, Australia, New Zealand.

There are numerous misprints in the names, but none of those we found were so bad as to make an address useless. As introduction a vocabulary of the principal terms in iron and steel metallurgy is given in eight different languages, according to the definitions of the Association for Testing Materials.

* * * * *

INTRODUCTION TO METALLURGICAL CHEMISTRY. For technical students. By J. H. Stansbie, B. Sc., F. I. C., Associate of Mason University College and lecturer in the Birmingham Municipal Technical School. Second edition. 252 pages; illustrated. Price, $1.25 net. New York: Longmans, Green & Co.

This little book is intended to be used in evening schools in preparatory courses, teaching the principles of chemistry in their application to metallurgy.

The plan of this book is simple. "It assumes that those who use it are practically interested in the common metals, and that they have no further knowledge of their properties than has been obtained by ordinary observation in a workshop or foundry, so that it is necessary to commence their scientific treatment at the very beginning. The physical properties of the metals and their alloys being fully treated in standard works on metallurgy, more than a passing notice is not devoted to this very important part of the study of metals. Brief references to the more useful properties will be found in different parts of the text. The greater portions of the chapters are taken up with a description of the chemical properties of the common metals, and in the development of chemical principles the metals are made to take as prominent a part as possible. The non-metals are, for the purpose of this book, regarded more as the servants of the metals than as their masters; but this is not from any want of appreciation of their importance, and it is hoped that the common ones are sufficiently described to make them quite familiar."

The book is mainly of a practical nature, so that the theoretical principles are taught by developing them from experiments, either from lecture demonstrations or from experiments made by the students themselves. Thus, the effects of air and water on metals are first studied. This is followed by a dis-

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WATER: Sources. Physical and Chemical Characteristics of Well Waters, River Waters, Surface Waters and Rain Water. Apparatus and Methods for Analysis. Special Tests for Oil. Practical Applications of Tests Results. Use of Softening Apparatus and Reagents.

WASTE GASES: Physical and Chemical Characteristics of Waste Gases. Collecting Gas Samples. Apparatus and Methods for Analysis. Applications and Use of Continuous and Recording Gas-testing Apparatus. Practical Applications of Gas Test Results.

APPENDIX: Rules for Sampling Fuel. Formula Calculating the Calorific Value. Use of Fuels of Low Calorific Value. Typical Tests of Exit Gases, etc. Index.

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